NASA CR-152336-2
(D. Chappell)

PRELIMINARY DESIGN STUDY OF ADVANCED COMPOSITE BLADE AND HUB AND NONMECHANICAL CONTROL SYSTEM FOR THE TILT-ROTOR AIRCRAFT

VOLUME 2: PROJECT PLANNING DATA

FEBRUARY 1980

Prepared Under Contract No. NAS2-10160
for
National Aeronautics and Space Administration
Ames Research Center

by

BOEING VERTOL COMPANY
A DIVISION OF THE BOEING COMPANY
PHILADELPHIA, PENNSYLVANIA 19142

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FOREWARD

The project planning data presented in the document are based on engineering design studies reported in Volume 1, and were performed by Boeing Vertol Company for the National Aeronautics and Space Administration, Ames Research Center, under NASA Contract NAS2-10160.

Mr. [illegible]. P. Chappell was the technical monitor, and Mr. H. R. Alexander was the Boeing Vertol program manager.

ABSTRACT

This document contains project planning data for a program to modify the XV-15 aircraft by designing, fabricating, and installing advanced composite blades (compatible with existing hub), an advanced composite hub, and a nonmechanical control system. The blades and hubs are such that no major modifications are required to the existing nacelle, power train, or airframe structure.

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1.0 INTRODUCTION

There is an increasing interest in V/STOL aircraft for military and special purpose civil applications. Advanced concepts, such as the tilt rotor provide improvements in speed, range, and payload, giving increased aircraft productivity, improved fuel economy, and improved mission effectiveness. The current XV-15 research aircraft project is aimed at verifying the feasibility of the tilt-rotor concept and the investigation of the basic stability, performance, and handling qualities of the vehicle. The XV-15 currently incorporates a rotor and control system based on 1968 technology. The use of advanced rotor systems with integrated rotor and airplane controls utilizing fly-by-wire concepts will further enhance tilt-rotor performance, maneuverability, gust sensitivity, ride comfort and rotor blade life.

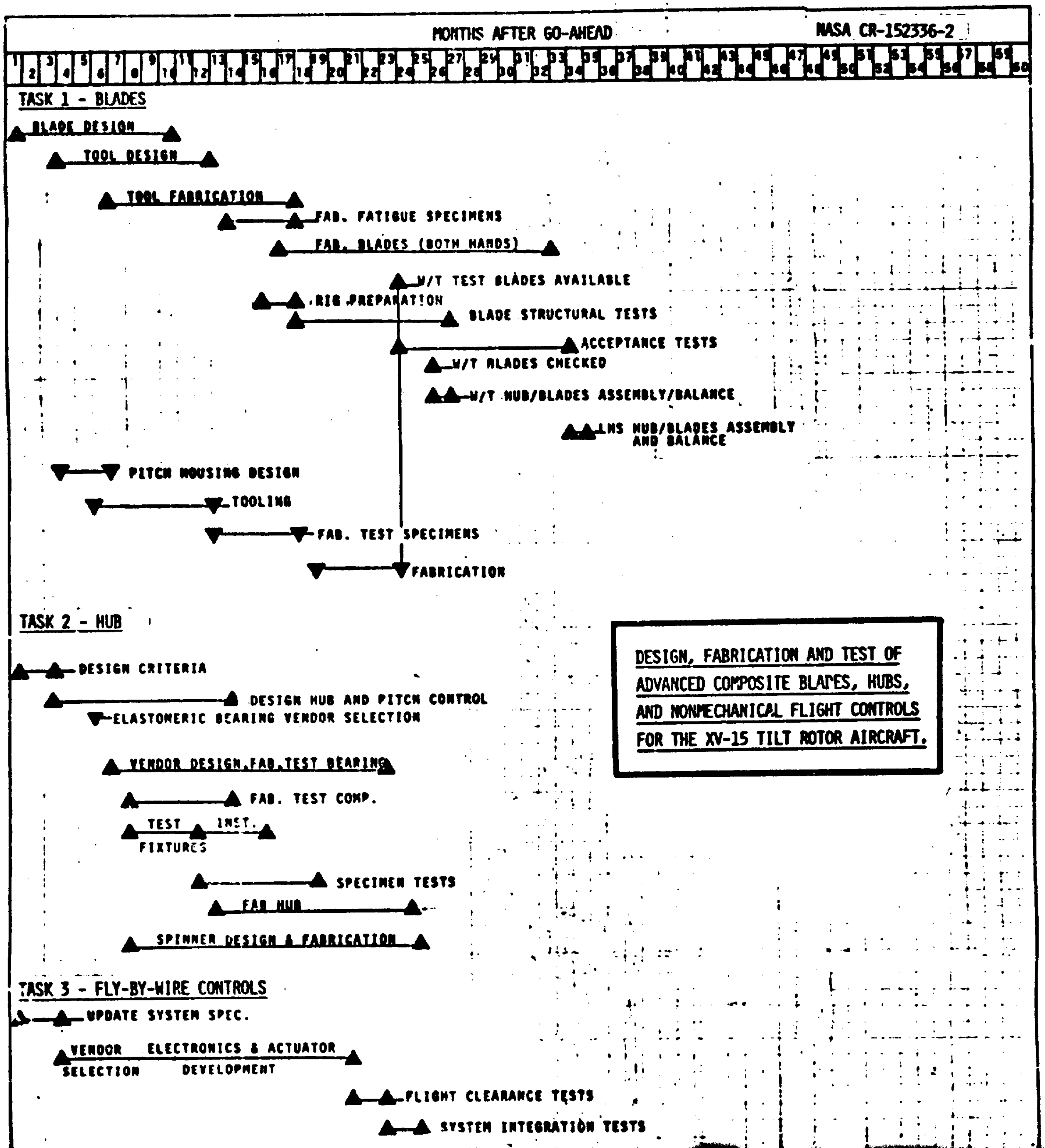
The Boeing Vertol Company, both in-house and under contract, has been developing the technology of advanced composite rotor systems, as well as integrated rotor/airplane control systems utilizing fly-by-wire concepts. These efforts have included both analytical and experimental studies and have indicated improved capabilities that will broaden the potential application of the tilt-rotor concept in the 1980's.

The purpose of this study performed under NASA Contract NAS2-10160 is to have Boeing Vertol Company provide the necessary preliminary design and planning information for a program to build advanced composite blades and hubs, and a fly-by-wire system for the XV-15 tilt rotor research aircraft.

This study is viewed as the first step in a possible program. It is a study to determine the best design of blades and hubs for the tilt-rotor aircraft, and to select and specify a nonmechanical control system to replace existing linkages, subject to the ground rule that no changes are permitted in the nacelle, drive train, or airframe. Step one also includes planning and estimating the cost of detail design, fabrication, testing and installation in the XV-15. Further steps, not addressed as part of the present study contract, would be for detail design, fabrication, and testing of the full-scale system; and step three would be installation of subject systems in one XV-15 aircraft, functional checkout and tiedown testing. This would be followed by a flight test program which is not defined in detail here.

The objectives of this study are: (a) to provide preliminary design data on an advanced composite rotor system and advanced composite hub, and on a state of the art nonmechanical control system; the blades and hubs are to result in enhanced fatigue strength, improved performance in hover and cruise, and improved reliability, maintainability, and repairability; (b) to submit an overall project plan for design, fabrication, wind tunnel testing, and investigations necessary to support modification of the XV-15 aircraft.

These objectives are the subject of the two volumes of the final report. The technical data are reported in Volume 1, (Reference 1) and the project planning and planning estimates of costs and schedule are reported herein. This document is considered proprietary to the Boeing Vertol Company.


MONTHS AFTER GO-AHEAD
TASK 1 - BLADES
BLADE DESIGN
TOOL DESIGN
TOOL FABRICATION
FAB. FATIGUE SPECIMENS
FAB. BLADES (BOTH HANDS)
W/T TEST BLADES AVAILABLE
RIG PREPARATION
BLADE STRUCTURAL TESTS
ACCEPTANCE TESTS
W/T BLADES CHECKED
W/T HUB/BLADES ASSEMBLY/BALANCE
LMS HUB/BLADES ASSEMBLY AND BALANCE
PITCH HOUSING DESIGN
TOOLING
FAB. TEST SPECIMENS
FABRICATION
TASK 2 - HUB
DESIGN CRITERIA
DESIGN HUB AND PITCH CONTROL
ELASTOMERIC BEARING VENDOR SELECTION
VENDOR DESIGN,FAB,TEST BEARING
FAB. TEST COMP.
TEST FIXTURES
INST.
SPECIMEN TESTS
FAB HUB
SPINNER DESIGN & FABRICATION
TASK 3 - FLY-BY-WIRE CONTROLS
UPDATE SYSTEM SPEC.
VENDOR SELECTION
ELECTRONICS & ACTUATOR DEVELOPMENT
FLIGHT CLEARANCE TESTS
SYSTEM INTEGRATION TESTS
DESIGN, FABRICATION AND TEST OF ADVANCED COMPOSITE BLADES, HUBS, AND NONMECHANICAL FLIGHT CONTROLS FOR THE XV-15 TILT ROTOR AIRCRAFT.

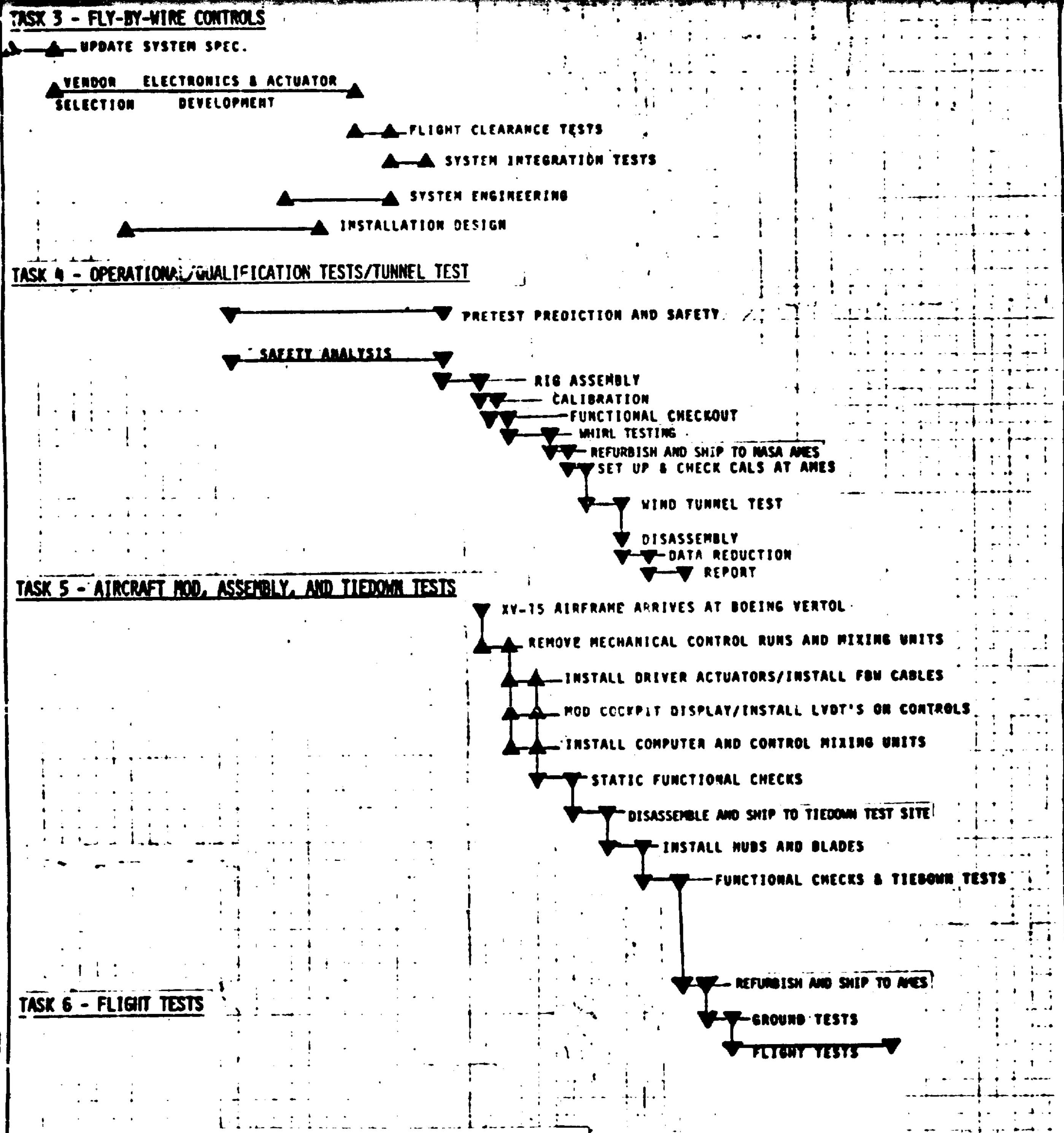


FIGURE 2.1 SCHEDULE OF PERFORMANCE

FOLDOUT FRAME 2

2.0 PROGRAM DESCRIPTION AND SCHEDULE

The planning data presented in this section of the report is guided by the broad program outlines defined in the contractual statement of work and repeated in the introduction to this report. This study assumes the production program for the blades will proceed subject to the results of the initial structural tests and prior to completion of the fatigue test program. The full-scale tunnel test is also regarded as a data acquisition procedure, and the blade fabrication program is not paced by the tests. The program schedule is shown in Figure 2.1. Alternative programs are feasible, and sufficient detail is provided in the cost data presented to permit estimation of alternative program costs. It is noted that it is unlikely that there will be full development of both the advanced composite hub, and the modified XV-15 gimball hub, and the plans downstream of detail design assume testing and fabrication of one or the other but not both.

2.1 Program Elements and Work Flow

To accomplish the subject program, the task outlined in the schedule shown in Figure 2.1 will be performed. While there are several possible approaches, we have selected the one which minimizes overall program cost. This involves committing the total program dollars prior to experimental demonstration for those program elements which are retained in the final program definition. It is believed that this is the correct approach because the purpose of the wind tunnel program is less validation of flight worthiness than evaluation of rotor performance and other properties. An alternative approach, in which full commitment awaited the outcome of the wind tunnel program, would stretch the program and increase cost. A second alternative would be to proceed directly to aircraft modification without an intervening single rotor wind tunnel demonstration. The full aircraft would then be tested in the 40' x 80' wind tunnel. This approach has the advantage that a fully modified aircraft is attained up to six months earlier. However the rate of spending would be higher.

The blades are composite hingeless blades with a two-pin retention. The blade tooling must be sufficiently durable to fabricate the total required (6 to 9 per side, plus structural test specimens and proof of tooling blades).

Modified pitch housings must be fabricated to provide a clevis attachment for the blade twin-pin wraparound retention. Fatigue testing using the tool proving blades and the flight pitch shaft pins and retention hardware is assumed prior to the wind tunnel test. This test will provide data on the whole root end assembly including composite and metal component data. Fatigue tests of an outer section of the blade will also be performed.

Hub - In the event that the new hub design is procured, a test specimen of the new hub will replace the pitch housing in the fatigue test procedure. A minimum of four hubs will be fabricated in addition to fatigue test specimens.

Fly-by-Wire Controls - It has been assumed that the design of the fly-by-wire system will be complete and that sufficient hardware (i.e. actuators) will be in hand for use in the wind tunnel test.

The fly-by-wire system uses driver actuators in conjunction with the power actuators of the present XV-15 installation, and the present plans call for digital rather than analog processing of control inputs.

Whirl Testing - It has been assumed that the semi-span wing and base adapter using during NASA Contract NAS2-6505 is available and that the Government will furnish this hardware free of charge. It is also assumed that an XV-15 nacelle assembly and power plant will be made available.

This rig will be assembled initially at Boeing Vertol for system integration, calibration and whirl testing. A 50-hour whirl test is envisioned. In the event that the existing gimballed hub is retained, the whirl test will be eliminated or curtailed to the point of being a functional checkout of instrumentation and controls under rotating conditions.

Tunnel Test - At completion of the functional checkout and/or whirl test, the rig will be disassembled, refurbished, and shipped to Ames Research Center for final testing. A test period of approximately five weeks in the tunnel is envisioned.

Aircraft Modification - An XV-15 airframe will be shipped to Boeing Vertol for modification. This will include replacement of mechanical control linkages and mixing boxes with fly-by-wire equipment, and the installation of driver actuators in the left hand nacelle. The right hand nacelle will be remounted on the airframe, and the left hand nacelle will be fitted with composite hub and blades.

Tiedown Test - Functional checkout and qualification testing of the control system and left hand hub will be performed with the aircraft mounted on an elevated ground test rig which permits the full range of nacelle tilt with the rotors turning. In the event that the Bell hub is retained, this test may be curtailed to be essentially a functional checkout of the fly-by-wire installation, and need not continue for the full duration of a rotor hub qualification test.

Flight Test - Following the tiedown test, the aircraft will be shipped to Ames Research Center for flight test. A nine-month program is envisioned, and during this time the rotor performance characteristics would be verified and fly-by-wire control parameters optimized.

2.2 Potential Alternative Programs

Complete Aircraft Tunnel Test - It is noted that the program outlined above is not unique. An alternative program which has many attractions is to proceed as fast as possible with the aircraft modification (without an intervening semi-spar tunnel test), and conduct a tunnel test of the complete aircraft. This has the advantage of providing a fully modified aircraft in the minimum time span, and would also provide the occasion for evaluation and checkout of other changes to the airframe (such as, those anticipated for drag reduction).

Dynamic Model Tests - The advanced composite blade design envisioned matches the essential dynamic properties of the XV-15 current blades, so that rotor-airframe dynamics should not be any more of an issue than at present.

In the detail design phase, we may accept some deviation in blade stiffness and frequency properties in order to minimize the use of graphite and/or titanium. In this event, it would be desirable to conduct scaled dynamic model

tests early in the program. This should probably be performed using an existing scaled dynamic model of the XV-15 with blades and/or hub modified to represent the proposed new design.

Planning and cost information on these alternatives or additional program elements can be provided if interest develops later.

3.0 WORK STATEMENT AND TASK DEFINITION FOR COST ESTIMATION

Ground Rules for Program Planning - There are three major components to the overall program. These relate to development and installation of composite blades, composite hubs, and a fly-by-wire control system for the XV-15.

Program plans and cost estimates are based on the execution of all three components concurrently. It should be noted that a program for fly-by-wire alone is feasible, and blade development can be undertaken with minor modifications to the existing hub. However, the composite hub design proposed depends on availability of compatible blades.

Basic Program and Options - Develop, manufacture, and test composite blades, composite hubs, fly-by-wire controls, and install in XV-15 aircraft.

Task 1 - Blades

a) Design: Provide detail design of the blade with a twin-pin retention and provide stress and frequency analyses to support the design. Design loads spectra and life calculations are to be provided with a fabrication sequence and procedure defined.

b) Tool Design: Tooling will be designed to fabricate and assemble the blade for both hands of rotation. The tool design shall be consistent with an expected production of ten blades of each hand.

c) Tool Fabrication: Fabricate or procure the blade tools to design of Item b.

d) Fabricate 1 R.H. and 1 L.H. tool proving blade.

   Fabricate 2 R.H. and 1 L.H. fatigue test blade including cuffs, instrumentation and tip fittings.

   Fabricate 6 R.H. and 6 L.H. flight worthy blades.

   Total - 17 blades

   Optionally fabricate additional 3 R.H. and 3 L.H. flight worthy blades.

   Total - 23 blades

e) Structural Tests: Using tool proving blades provide deflection, frequency, mass distribution and cg and shear center data for the design. Fatigue test the root end and a blade outer section to be selected.

f) Acceptance Tests: For the three wind tunnel test blades check:

   (1) blade frequencies,
   (2) blade weight and cg location,
   (3) stiffness data, and
   (4) aerodynamic precision.

g) Assemble three blades in each hub from Task 2, and balance the whole rotating assembly.

Task 2 - Hub

a) Review and revise design criteria and document.

b) Provide detail design of hub, pitch shaft, upper controls interface.

c) Select a vendor and provide liaison through vendor design and test of elastomeric bearings.

d) Fabricate 3 hub proof of tooling and fatigue test specimens and provide experimental verification of the design.

e) Fabricate 5 flight worthy hubs and pitch shafts. Buy elastomeric bearings to support the program. Total basic program 8 hubs. Optionally fabricate an additional 2 flight worthy spare hubs. Option total 10.

f) Inspect components - assembly (see Item g of Task 1).

g) Spinner: design and fabricate 4 spinners.

Task 3 - Fly-by-Wire Controls

a) Review and update system specification.

b) Define details of thrust management system.

c) Define implementation details (actuator requirements, SCAS interface, gust alleviation interface capability, etc.).

d) Define wind tunnel test configuration.

e) System engineering (location of units/interconnect concept cockpit interface, etc.).

f) Define SCAS system.

g) Solicit vendor proposals/select vendors.

h) Design liaison/vendor flight qualification tests.

i) Procure aircraft equipment.

j) Laboratory system integration tests.

k) Prepare system schematics, assembly and installation drawings.

l) Install equipment in XV-15 aircraft.

m) Provide controls support for wind tunnel and ground testing.

Task 4 - Operational/Qualification Tests

Prior to wind tunnel testing operational and qualification whirl tests will be carried out at Boeing. This test will use the right hand nacelle package from the XV-15 aircraft scheduled for modification. This package will be installed

on a semi-span test wing structure. The new hub and right-hand blades will be mounted along with fly-by-wire controls for engine and blade pitch control. The test objective is to: a) to provide whirl endurance data, and b) to ensure tunnel safety and a level of confidence in completing wind tunnel data runs without mechanical, electrical, or hydraulic malfunction. (See Section 3.1 for discussion of actuator installation in nacelle.)

Specific objectives are as follows:

- Safety. Demonstrate integrity of rotor load carry-through structure, rotor shaft/hub connection, elastomeric bearings and retention hardware. Demonstrate the operation of the rotor and engine control system and establish rotating system frequencies to verify aeroelastic predictions. Measure loads due to cyclic and collective excursions. Check control safety logic.

- Reliability. Demonstrate the following controls:

  - operation under vibratory and loaded conditions
  - precision and repeatability

- Rotor System

  - cuff and tip retention
  - blade instrumentation

- Transmission

  - lubrication scavenging
  - lubrication feed pressures, cooling and filtration

The whirl-test programs defined below will be conducted entirely on the wind tunnel configuration; supported vertically and outside the tunnel. Facilities and services will be identical to those planned for tunnel use.

A. Blade-off Test

Without the rotor blade installed, rpm will be built up to hover maximum and held until lubrication oil temperatures and pressures stabilize. This is to check functioning and adequacy of lubrication system in the tunnel test orientation. Visual examination of boxes will determine oil tightness, and accelerometer on output shaft bosses will be monitored. No-load test run is estimated to require two hours. Rotor will be installed upon successful completion.

B. Blades-on Test

Load and rpm will be built up to hover maximum and sustained for five hours with the nacelle in both hover and cruise position. A rotor moment load spectrum will be imposed. Following this, the blades and hubs will be removed and the hub will be disassembled and inspected for wear and tear in the leaf spring assembly and for set or other deterioration in the elastomeric bearings. Retention pin locations will also be inspected. Following this initial inspection, the rotor will be reassembled and reinstalled. A further 25 hours of running under maximum torque conditions

anticipated in the wind tunnel will be performed. External inspections will be conducted at 5-hour intervals during this test. At the conclusion of this test, the rotor will be disassembled again and inspected. Following inspection, reassembly, and reinstallation, a further twenty-five hours of running under both cruise and hover loads and speeds will be performed. At the conclusion of this test, a complete disassembly and analytical inspection of components will be accomplished.

The spare hubs will be installed in the rig and run for five hours at hover maxima. A partial disassembly and inspection will be accomplished.

The fifty-five hour set of dynamic components will be refurbished with zero-time components as required, reassembled and run for two hours under load. This will complete the testing prior to tunnel usage.

Data to be taken during the fifty-five hours of load testing will include:

- Lubrication temperatures, pressures, oil flows
- Filter inspection results (five-hour intervals)
- Debris records
- Rotor torque
- Rotor hub moments and forces
- Blade bending loads
- RPM
- Nacelle position
- Gear case accelerometer readings
- Control system position data
- Fuel flows
- Engine temperatures
- Subsystem performance data
- Wing bending and accelerations
- Disassembly/inspection findings

After completion of these tests, the rig, blades, hub, nacelle, etc., are refurbished, reassembled, and functionally checked out, then disassembled and shipped to the 40' x 80' wind tunnel at NASA Ames.

<u>Task 4.1 - NASA Ames Wind Tunnel Test</u>

<u>Task 4.1.1 - Pretest Preparation</u>

a) Liaison with 40' x 80' wind tunnel staff to establish test ground rules and safety requirements.

b) Test plan layout and technology predictions to satisfy test safety requirements and project objectives.

c) System safety analysis.

d) Assemble the test rig at Ames, install blades, connect controls and instrumentation, and perform:

(1) Functional Tests (nonrotating)

- control system static operation and position calibrations
- clearance and binding checks for full range of control travels and nacelle positions
- pressure hose leakage tests
- instrumentation calibrations
- alignment spinner

Task 4.1.1 also includes the effort necessary to provide test planning, liaison with the 40- by 80-foot tunnel staff, and pretest predictions and safety analysis.

Task 4.1.2 - Wind Tunnel Test

NOTE: Items a) through d) are performed offsite at NASA Ames.

a) Assemble test rig at NASA Ames 40' x 80' wind tunnel and perform repeats of functional and calibration checks.

b) Test planning and safety review.

c) Wind Tunnel Test - For the purpose of estimating costs, assume a tunnel occupancy of five weeks/two shifts per day. This is additional to a three-week period, two shifts a day, prior to life-in for reassembly, instrumentation checks, and static system checks.

Conduct a wind tunnel test to meet the following objectives:

- Demonstrate the aeroelastic compatibility of the rotor/nacelle/wing assembly

- Demonstrate the flight envelope boundaries within the tunnel capability

- Define infinite life fatigue loads flight limits

- Demonstrate reliable operation of flight hardware

d) Disassemble and ship to Vertol.

e) Analyze wind tunnel data and prepare Task 4 2 report.

Task 5 - XV-15 Modification, Assembly, and Tiedown Test

In this stage of the program, the XV-15 is modified to the new hub and blade configuration, the fly-by-wire system is installed and a tiedown test performed, after which the aircraft is considered ready for flight test.

Task 5.1 - Aircraft Modification and Assembly

a) Receive XV-15 aircraft at Boeing Vertol (assume that the Bell blades and hubs are removed).

b) Remove mechanical control runs, actuators and mix boxes, and store.

c) Install fly-by-wire actuators and route fly-by-wire cables.

d) Modify cockpit display/install control transducers.

e) Install DELS units.

f) Refurbish right hand side nacelle.

g) Install Boeing Vertol hub on aircraft.

h) Static functional tests.

i) Ship to tiedown area and install on aircraft.

Task 5.2 - Fly-by-Wire Controls

a) Complete actuator procurement for aircraft program.

b) Vendor design of mixing units and procure aircraft control units and transducers, connectors, wire, etc.

c) Perform liaison for Item b).

d) Perform system integration tests.

Task 5.3

The aircraft components (e.g., nacelle package, rotor, hubs and control actuators) used in the wind tunnel are disassembled, inspected and refurbished with new seals, rod ends, etc., as necessary. Blade instrumentation is repaired. Inspect and refit aircraft scavenge configuration. Inspect all lines, wires, connections, and plugs for looseness, chafing and wear, and replace as necessary. Reassemble and install on XV-15 airframe.

Remove left hand nacelle package of same aircraft and modify to install fly-by-wire actuators, control linkages, and wiring. Remove XV-15 hub and install new composite hub. Reconnect pitch controls. Reinstall on XV-15 airframe.

Task 5.4 - Test Preparation

a) Test planning, pretest predictions and safety analysis.

b) Prepare ground test pad; needs to be raised to allow operation in cruise mode. Requires fuel supply, hydraulic supply, safety precautions. (Assume available facilities.)

c) Prepare a full force simulation of the aircraft and provide pilot training through test procedures and emergency procedures.

d) Calibration of aircraft instrumentation.

Task 5.5 - Tiedown Tests

a) Left hand side nacelle "no load" test - Run left hand side transmission for two hours with no blades and the cross shaft disconnected.

b) With blades on and the cross shaft connected, perform operational tests at low power settings to verify controls operating characteristics.

c) Run tie-down test for five hours at maximum hover power, $i_N = 90°$. Inspect blades and hub for wear, set or other damage.

d) Refit left-hand side of blades and hubs, and run for twenty-five hours. External inspections every five hours - $i_N = 90°$.

e) Inspect transmission, actuators, blades, and hubs. Set up at $i_N = 70°$ and run at maximum anticipated torque for this nacelle angle for twenty-five hours.

f) Repeat e) at $i_N = 50°$, $30°$ and $0°$.

g) Inspect blades, hubs, controls, and refurbish as necessary. Remove blades and wing, and ship to NASA Ames.

Task 6 - Flight Test

It is assumed that flight testing will be performed at NASA Ames.

a) Reassemble aircraft - static checks and calibrations.

b) Ground run-up checks.

c) Taxi tests.

d) Flight Testing - for flight envelope expansion and demonstration. For the purpose of estimating costs, assume a nine-month program with a Boeing support team offsite.

e) Report requirements.

Task 7 - Management

A management level of effort is assumed throughout the program.

3.1 Notes on Fly-by-Wire Actuator Installation

This section discusses engineering design and liaison to replace the existing input mechanical system to the flight controls power actuators.

The existing input systems would be replaced by Boeing Vertol Company designed electrically activated Dual-Driver actuators. These units would be mounted in close proximity to existing flight control power actuators.

Detail layouts, design, and installation drawings would be prepared and engineering liaison and support would be provided for the following items:

(1) Engineering instructions to identify and remove existing hardware not required for the new input system.

(2) Engineering layouts and drawings to modify the cockpit displays and controls to accommodate transducers, panels, etc. to reflect revised control systems.

(3) Collective Actuator - The existing power actuator is located in cavity at centerline of rotor transmission. Support brackets and bellcranks are required for the Dual Driver actuator mounted directly to adjacent nacelle structure and/or transmission.

(4) Longitudinal Cyclic Actuator - The existing power actuator is located in the nacelle adjacent ot the cowling door panel. Support brackets are required for the Dual Driver actuator mounted directly to adjacent nacelle structure and/or transmission. A rework of the fiberglass cowling door panel is required to provide clearance for the Dual Driver actuator.

(5) Flaperon Actuator - The existing power actuator is located in the mid-span of wing. Support brackets are required for the Dual Driver actuator mounted directly to adjacent wing structure.

(6) Rudder Actuator - The existing power actuator is located in the aft section of the fuselage. Support brackets are required for the Dual Driver actuator mounted directly to adjacent fuselage structure.

(7) Elevator Actuator - The existing power actuator is located in the aft section of the fuselage. Support brackets are required for the Dual Driver actuator mounted directly to adjacent fuselage structure.

(8) Cockpit Flight Controls - Transducers required to replace the mechanical controls at the following locations:

(a) Yaw control pedals
(b) Power lever
(c) Pitch control stick
(d) Roll lever

(9) Installation of electrical boxes required for the new input system.

(a) Approximately 8 boxes.

(10) Engineering Liaison.

4.0 MANHOUR ESTIMATES

4.1 Engineering Manhours

This section presents engineering manhour estimates by Task for the program defined in Section 3.0.

These are broken down by labor grade and skill and travel requirements are also identified. An Engineering effort of 152,360 manhours is envisioned for the total program as indicated in Table 4.0. Engineering manhour estimates for individual tasks and by labor grade and calendar year are presented in Tables 4.1 through 4.8.

4.2 Manufacturing Manhours

Estimates for manufacturing manhours by Task and department are given in Table 4.9. A total of 340,262 manufacturing manhours is estimated for the extended program option of 23 blades and 10 hubs (includes proof of tooling and structural test specimens). The basic program of 17 blades and 8 hubs would require 311,242 manufacturing manhours.

TABLE 4.0

ENGINEERING MANHOUR ESTIMATE
TOTAL PROGRAM SUMMARY BY TASK

TASK 1. - ROTOR BLADES	19,900 M/H	
TASK 2. - ROTOR HUBS	21,700	
TASK 3. - FLY-BY-WIRE CONTROL SYSTEM	30,280	
TASK 4.0 - OPERATIONAL/QUAL. TESTING	8,680	
TASK 4.1 - NASA AMES WIND TUNNEL TEST	11,600	
TASK 5. - XV-15 MOD., ASSY, AND TIEDOWN TEST	17,400	
TASK 6. - FLIGHT TEST PROGRAM	16,400	
TASK 7. - MANAGEMENT	26,400	
TOTAL PROGRAM ENGINEERING (PLANNING)		152,360 M/H

LABOR GRADE BREAKOUT

L/G 72	9,070 M/H
L/G 74	47,360
L/G 76	41,520
L/G 78	32,580
L/G 10	12,760
L/G 06	9,070
TOTAL ENGR'G	152,360 M/H

COMPUTER PROGRAMMING REQUIREMENTS

NONE

TRAVEL REQUIREMENTS

SEE ATTACHED SHEETS

TABLE 4.1

ENGINEERING MANHOUR ESTIMATE
TASK 1. ROTOR BLADES

WORK ITEMS	BLADE DESIGN	ENGR'G LABS	ROTOR STRESS	WEIGHTS	M&P	DYNAMICS	AERO	TOTAL
BLADE DESIGN	4,840	-	2,900	400	1,460	280	280	10,160
TOOL DESIGN SUPPORT	360	-	-	-	-	-	-	360
BLADE MFG. LIAISON	1,760	-	-	-	-	-	-	1,760
DOCUMENTATION	160	-	-	-	-	-	-	160
SUPV. SECR., ADMIN.	360	-	-	-	-	-	-	360
TOOL PROVING BLADE	-	80	-	-	-	-	-	80
STATIC LOAD TEST	40	440	40	-	30	-	-	550
ROOT END FATIGUE	160	1,660	160	-	100	-	-	2,080
INTERMEDIATE FATIGUE	160	1,660	160	-	100	-	-	2,080
TIP END FATIGUE	160	1,660	160	-	100	-	-	2,080
BLADE ACCEPTANCE TESTS	10	210	10	-	-	-	-	230
TOTAL TASK 1.	8,010	5,710	3,430	400	1,790	280	280	19,900

LABOR GRADE BREAKOUT

L/G 72	930 M/H
L/G 74	4,940
L/G 76	5,980
L/G 78	5,060
L/G 10	2,060
L/G 6	930
TOTAL ENGR'G	19,900 M/H

COMPUTER PROGRAMMING REQUIREMENTS

NONE

TRAVEL REQUIREMENTS

1. TWO (2) ONE-MAN/ONE WEEK TRIPS TO NASA AMES, SAN FRANCISCO, CALIF.

TABLE 4.2

ENGINEERING MANHOUR ESTIMATE
TASK 2. ROTOR HUBS

WORK ITEMS	ROTOR HUB DESIGN	ENGR'G LABS	ROTOR STRESS	WEIGHTS	M&P	TOTAL
HUB DESIGN	8,940	-	3,970	640	790	14,340
SPINNER DESIGN	1,000	-	500	80	100	1,680
ELAST. BRG. VENDOR LIAISON	640	-	-	-	-	640
MFG. LIAISON	2,040	-	-	-	-	2,040
HUB/SHAFT JOINT FATIGUE	100	1,100	100	-	80	1,380
HUB FATIGUE TESTING	60	720	60	-	60	900
BLADE/HUB BALANCING	10	80	10	-	-	100
SUPV., SECR., ADMIN.	620	-	-	-	-	620
TOTAL TASK 2.	13,410	1,900	7,640	720	1,030	21,700

LABOR GRADE BREAKOUT

L/G 72	1,040 M/H
L/G 74	5,800
L/G 76	6,520
L/G 78	5,140
L/G 10	2,160
L/G 06	1,040
TOTAL ENGR'G	21,700 M/H

COMPUTER PROGRAMMING REQUIREMENTS

NONE

TRAVEL REQUIREMENTS

1. THREE (3) TWO MAN/ONE WEEK TRIPS TO BARRY, BOSTON, MASS.
2. THREE (3) ONE MAN/THREE DAY TRIPS TO BARRY, BOSTON, MASS.
3. TWO (2) ONE MAN/ONE WEEK TRIPS TO NASA AMES, SAN FRANCISCO, CALIF.
4. TWO (2) ONE MAN/ONE WEEK TRIPS TO LOS ANGELES, CALIF.
5. TWO (2) ONE MAN/THREE DAY TRIPS TO CHICAGO, ILLINOIS

TABLE 4.3

ENGINEERING MANHOUR ESTIMATE
TASK 3. FLY-BY-WIRE CONTROL SYSTEM

WORK ITEMS	EFCS DESIGN	OTHER DESIGN	SERVO LABS	AERO FLY QUAL	A/F STRESS	WEIGHTS	M&P	TOTAL
SYSTEM SPECS., VENDOR PROPOSALS, HDWRE LIAISON, SYSTEM CONFIG. DEV.	11,360	4,400	-	880	2,240	1,260	640	20,780
BELL XV-15 MOD. DESIGN	1,200	3,640	-	400	1,040	380	200	6,860
SUPV., SECR., ADMIN.	640	400	-	-	-	-	-	1,040
LAB. INTEGRATION TESTING	200	-	1,200	200	-	-	-	1,600
TOTAL TASK 3.	13,400	8,440*	1,200	1,480	3,280	1,640	840	30,280

*MECH. FLT. CONTROLS DESIGN	1,200 M/H
HYDRAULICS DESIGN	3,640
AIRFRAME DESIGN	720
ELECT. & WIRING DESIGN	2,880
	8,440 M/H

COMPUTER REQUIREMENTS

NONE

LABOR GRADE BREAKOUT

L/G 72	1,500 M/H
L/G 74	8,220
L/G 76	9,060
L/G 78	6,900
L/G 10	3,100
L/G 06	1,500

TOTAL ENGR'G 30,280 M/H

TRAVEL REQUIREMENTS

ELECT. FLIGHT CONTROLS
a. TWELVE (12) TWO-MAN/ONE WEEK TRIPS TO BERTEA, LOS ANGELES, CALIF.
b. TWELVE (12) ONE-MAN/ONE WEEK TRIPS TO BERTEA, LOS ANGELES, CALIF.
c. ONE (1) TWO-MAN/ONE WEEK TRIP TO NASA AMES; SAN FRANCISCO, CALIF.

MECH. FLIGHT CONTROLS
a. FOUR (4) TWO-MAN/ONE WEEK TRIPS TO BERTEA, LOS ANGELES, CALIF.
b. FOUR (4) ONE-MAN/ONE WEEK TRIPS TO BERTEA, LOS ANGELES, CALIF.
c. ONE (1) ONE-MAN/ONE WEEK TRIP TO NASA AMES; SAN FRANCISCO, CALIF.

HYDRAULICS & AIRFRAMES
a. TWO (2) TWO-MAN/ONE WEEK TRIPS TO BERTEA, LOS ANGELES, CALIF.
b. TWO (2) TWO-MAN/ONE WEEK TRIPS TO BERTEA, LOS ANGELES, CALIF.
c. ONE (1) TWO-MAN/ONE WEEK TRIP TO NASA AMES; SAN FRANCISCO, CALIF.

ELECTRICAL
a. TWO (2) TWO-MAN/ONE WEEK TRIPS TO BERTEA, LOS ANGELES, CALIF.
b. TWO (2) ONE-MAN/ONE WEEK TRIPS TO BERTEA, LOS ANGELES, CALIF.
c. ONE (1) ONE-MAN/ONE WEEK TRIP TO NASA AMES; SAN FRANCISCO, CALIF.
d. THREE (3) ONE-MAN/THREE DAY TRIPS TO CHICAGO, ILL.

TABLE 4.4

ENGINEERING MANHOUR ESTIMATE
TASK 4.0 OPERATIONAL/QUALIFICATION TESTS

WORK ITEMS	DESIGN GROUPS	STRUCT TECHN.	OTHER TECHN.	ENGR'G LABS	PROJECTS	TOTALS
PRE-TEST PREDICTIONS AND DATA PREPARATION	-	400	1,040	320	-	1,760
TEST RIG SYST. SAFETY ANAL.	-	-	-	-	240	240
TEST RIG PREPARATION, INSTR. ASSEMBLY AND CHECKOUT	160	160	200	2,080	-	2,600
TESTING	320	320	400	2,080	-	3,120
ANAL AND REPORTS	80	80	80	240	-	480
RIG DISASSEMBLY, REFURBISH AND SHIP TO AMES	80	40	-	360	-	480
TOTAL TASK 4.	640	1,000	1,720	5,080	240	8,680

LABOR GRADE BREAKOUT

L/G 72	440 M/H
L/G 74	1,900
L/G 76	2,500
L/G 78	2,500
L/G 10	900
L/G 06	440
TOTAL ENGR'G	8,680 M/H

COMPUTER PROGRAMMING REQUIREMENTS

NONE

TRAVEL REQUIREMENTS

NONE

TABLE 4.4.1

ENGINEERING MANHOUR ESTIMATE
TASK 4.1 NASA AMES WIND TUNNEL TEST

WORK ITEMS	DESIGN GROUPS	STRUCT TECHN	OTHER TECHN	ENGR'G LABS	WIND TUNNEL	PROJECTS	TOTAL
NASA AMES LIAISON	-	-	-	80	-	80	160
PRE-TEST PREDICT/DATA PREP	-	400	1,040	-	320	-	1,760
TEST RIG SAFETY ANALYSIS	-	-	-	-	-	240	240
RIG TEST PREPARATION	80	320	-	1,600	-	-	2,000
RIG ASSY, CHECKOUT, TEST	320	320	320	1,920	-	-	2,880
RIG DISASSEMBLY/SHIP	80	80	-	320	-	-	480
ASSY, FUNCT. CHECKS @ AMES	80	-	40	240	-	-	360
WIND TUNNEL TEST @ AMES	160	40	120	960	-	-	1,280
LIFT OUT, DISASSEMBLY/SHIP	-	-	-	80	-	-	80
TEST SUPPORT, DATA REDUCTION, ANAL. & REPORT @ B/V	720	120	160	-	800	560	2,360
TOTAL TASK 4.1	1,440	1,280	1,680	5,200	1,120	880	11,600

LABOR GRADE BREAKOUT

L/G 72	640 M/H
L/G 74	2,560
L/G 76	3,320
L/G 78	3,240
L/G 10	1,200
L/G 06	640
TOTAL ENGR'G	11,600 M/H

COMPUTER PROGRAMMING REQUIREMENTS

NONE

TRAVEL REQUIREMENTS

1. ENGR'G LABS
   a. ONE (1) TWO-MAN/EIGHT WEEKS TRIP TO NASA AMES; SAN FRANCISCO, CALIF.
   b. ONE (1) FOUR-MAN/FOUR WEEK TRIP TO NASA AMES; SAN FRANCISCO, CALIF.

2. DESIGN GROUPS
   a. FIFTEEN (15) ONE-MAN/THREE DAY TRIPS TO NASA AMES

3. TECHNOLOGY GROUPS
   a. FOUR (4) ONE-MAN/THREE DAY TRIPS TO NASA AMES; SAN FRANCISCO, CALIF.

TABLE 4.5

ENGINEERING MANHOUR ESTIMATE
TASK 5. XV-15 MOD. , ASSY, & TIE-DOWN TEST

WORK ITEMS	DESIGN GROUPS	STRUCT TECHN	OTHER TECHN	FLIGHT TEST	ENGR'G LABS	PROJECT	TOTAL
AIRCRAFT PREPARATION AT B/V	680	340	340	3,040	-	-	4,400
TEST RIG & "STUFFING" DESIGN	1,600	800	320	-	2,400	-	5,120
RIG FAB LIAISON	100	-	-	-	700	-	800
TEST PLAN/CALIBRATE INSTR	-	-	-	960	360	-	1,320
TIEDOWN TESTING AT AMES	960	480	480	3,840	-	-	5,760
TOTAL TASK 5.	3,340	1,620	1,140	7,840	3,460		17,400

LABOR GRADE BREAKOUT

L/G	72	920 M/H
L/G	74	3,740
L/G	76	5,140
L/G	78	4,940
L/G	10	1,740
L/G	06	920

TOTAL ENGR'G 17,400 M/H

COMPUTER PROGRAMMING REQUIREMENTS

NONE

TRAVEL REQUIREMENTS

1. FIVE (5) TWO-MAN/THREE DAY TRIPS TO NASA AMES, SAN FRANCISCO, CALIF.
2. ONE (1) SIX-MAN /TEN WEEK TRIP TO NASA AMES, SAN FRANCISCO, CALIF.
3. ONE (1) SIX-MAN/FOURTEEN WEEK TRIP TO NASA AMES, SAN FRANCISCO, CALIF.

TABLE 4.6

ENGINEERING MANHOUR ESTIMATE
TASK 6. FLIGHT TEST PROGRAM

WORK ITEMS	DESIGN GROUPS	STRUCT TECHN.	OTHER TECHN.	FLIGHT TEST	PROJECT	TOTALS
DISASSEMBLY, REFURBISHMENT SHIPMENT TO AMES (FROM TIEDOWN AREA)	720	180	180	1,080	-	2,160
AIRCRAFT ASSEMBLY, STATIC TESTS, CALIB., TAXI TESTS, GROUND TESTS AND FLIGHT TESTING @ AMES	720	360	360	5,040	-	6,480
SUPPORT OF FLIGHT TEST @ B/V	3,600	360	360	2,160	-	6,480
FINAL REPORTS	320	160	160	320	320	1,280
TOTAL TASK 6.	5,360	1,060	1,060	8,600	320	16,400

LABOR GRADE BREAKOUT

L/G 72	800 M/H
L/G 74	5,800
L/G 76	5,800
L/G 78	1,600
L/G 10	1,600
L/G 06	800

TOTAL ENGR'G 16,400 M/H

COMPUTER PROGRAMMER REQUIREMENTS

NONE

TRAVEL REQUIREMENTS

1. FLIGHT TEST GROUP
   a. SIX (6) TWO MAN/TWO WEEK TRIPS TO NASA AMES, SAN FRANCISCO, CALIF.
   b. NINE (9) THREE MAN/THIRTEEN WEEK TRIPS TO NASA AMES, SAN FRANCISCO, CALIF.
   c. SIX (6) ONE MAN/SIX WEEK TRIPS TO NASA AMES, SAN FRANCISCO, CALIF.

2. DESIGN GROUPS
   a. NINE (9) ONE MAN/TWO WEEK TRIPS TO NASA AMES, SAN FRANCISCO, CALIF.
   b. SIX (6) ONE MAN TWO WEEK TRIPS TO NASA AMES, SAN FRANCISCO, CALIF.

3. TECHNOLOGY GROUPS
   a. SIX (6) ONE MAN/TWO WEEK TRIPS TO NASA AMES, SAN FRANCISCO, CALIF.
   b. SIX (6) ONE MAN/TWO WEEK TRIPS TO NASA AMES, SAN FRANCISCO, CALIF.

TABLE 4.7

ENGINEERING MANHOUR ESTIMATE
TASK 7. MANAGEMENT

WORK ITEMS	PROJECT	SECRETARY	TECHN MGR	TEST MGR	DATA MGMT	ENGR'G OPS	TOTAL
PROVIDE PROGRAM DIRECTION	8,000	4,000	4,000	4,000			20,000
RELEASE, CONTROL, TRACK, ETC.	-	-	-	-	1,720	4,680	6,400
TOTAL TASK 6.	8,000	4,000	4,000	4,000	1,720	4,680	26,400

LABOR GRADE BREAKOUT

L/G	72	2,800 M/H
L/G	74	14,400
L/G	76	3,200
L/G	78	3,200
L/G	10	-
L/G	06	2,800

TOTAL ENGR'G 26,400 M/H

COMPUTER PROGRAMMING REQUIREMENTS

NONE

TRAVEL REQUIREMENTS

1. TEN (10) TWO-MAN/THREE DAY TRIPS TO NASA AMES; SAN FRANCISCO, CALIF.
2. NINE (9) TWO-MAN/ONE WEEK TRIPS TO FORT DIX, N. J.
3. NINE (9) ONE-MAN/ONE WEEK TRIPS TO FORT DIX, N. J.
4. ONE (1) ONE-MAN/EIGHT WEEK TRIP TO NASA AMES; SAN FRANCISCO, CALIF.
5. ONE (1) ONE-MAN/FOUR WEEK TRIP TO NASA AMES; SAN FRANCISCO, CALIF.

TABLE 4.8

MANHOUR ESTIMATE

BY LABOR GRADE, BY TASK, BY CALENDAR YEAR

PROPOSAL ACTION RESPONSE

DIRECT COST INPUT · DEPARTMENT ENGINEERING

PREP. BY: G. R. Miller DATE 1-10-80

APPROVED BY: H. R. Alexander 1-10-80

CAP: 7776R1 - ADVANCED COMPOSITE BLADES, HUBS AND NON-MECHANICAL CONTROLS FOR TILT ROTOR AIRCRAFT		CALENDAR 1981	CALENDAR 1982	CALENDAR 1983	CALENDAR 1984	CALENDAR 1985		TOTAL ENGINEERING MANHOURS
TASK 1 ROTOR BLADES								
LABOR GRADE 72		560 M/H	240 M/H	130 M/H				930 M/H
LABOR GRADE 74		2 760	1 180	1 000				4 940
LABOR GRADE 76		3 360	1 440	1 180				5 980
LABOR GRADE 78		2 800	1 200	1 060				5 050
LABOR GRADE 10		1 160	500	400				2 060
LABOR GRADE 06		560	240	130				930
SUB-TOTAL TASK 1.		11 200 M/H	4 800 M/H	3 900 M/H				19 900 M/H
TASK 2. ROTOR HUBS								
LABOR GRADE 72		750 M/H	270 M/H	20 M/H				1 040 M/H
LABOR GRADE 74		4 100	1 620	80				5 800
LABOR GRADE 76		4 580	1 800	140				6 520
LABOR GRADE 78		3 500	1 520	120				5 140
LABOR GRADE 10		1 520	540	100				2 160
LABOR GRADE 06		750	270	20				1 040
SUB-TOTAL TASK 2.		15 200 M/H	6 020 M/H	480 M/H				21 700 M/H
TASK 3. FLY-BY-WIRE CONTROL SYSTEM								
LABOR GRADE 72		760 M/H	720 M/H	20 M/H				1 500 M/H
LABOR GRADE 74		4 080	4 000	140				8 220
LABOR GRADE 76		4 560	4 400	100				9 060
LABOR GRADE 78		3 480	3 360	60				6 900
LABOR GRADE 10		1 560	1 500	40				3 100
LABOR GRADE 06		760	720	20				1 500
SUB-TOTAL TASK 3.		15 200 M/H	14 700 M/H	380 M/H				30 280 M/H
TASK 4.0 OPERATIONAL/QUALIFICATION TESTS								
LABOR GRADE 72			100 M/H	340 M/H				440 M/H
LABOR GRADE 74			400	1 500				1 900
LABOR GRADE 76			560	1 940				2 500
LABOR GRADE 78			560	1 940				2 500
LABOR GRADE 10			200	700				900
LABOR GRADE 06			100	340				440
SUB-TOTAL TASK 4.0			1 920 M/H	6 760 M/H				8 680 M/H

FORM 49102 (8/67)

TABLE 4.8

MANHOUR′ TIMATE

BY LABOR GRADE, BY TASK, BY CALENDAR YEAR

PROPOSAL ACTION RESPONSE

DIRECT COST INPUT - DEPARTMENT ENGINEERING

PREP. BY: G. R. Miller DATE 1-10-80

APPROVED BY: H. R. Alexander 1-10-80

CAP: 7776R1 - ADVANCED COMPOSITE BLADES, HUBS AND NON-MECHANICAL CONTROLS FOR TILT ROTOR AIRCRAFT	CALENDAR 1981	CALENDAR 1982	CALENDAR 1983	CALENDAR 1984	CALENDAR 1985	TOTAL ENGINEERING MANHOURS
TASK 4.1 NASA AMES WIND TUNNEL TEST						
LABOR GRADE 72			610 M/H	30 M/H		640 M/H
LABOR GRADE 74			2 460	100		2 560
LABOR GRADE 76			3 180	140		3 320
LABOR GRADE 78			3 120	120		3 240
LABOR GRADE 10			1 140	60		1 200
LABOR GRADE 06			610	30		640
SUB-TOTAL TASK 4.1			11 120 M/H	480 M/H		11 600 M/H
TASK 5. XV-15 MOD. ASSY AND TIEDOWN TEST						
LABOR GRADE 72			600 M/H	320 M/H		920 M/H
LABOR GRADE 74			2 480	1 260		3 740
LABOR GRADE 76			3 460	1 680		5 140
LABOR GRADE 78			3 340	1 600		4 940
LABOR GRADE 10			1 160	580		1 740
LABOR GRADE 06			600	320		920
SUB-TOTAL TASK 5.			11 640 M/H	5 760 M/H		17 400 M/H
TASK 6. F LIGHT TES, PROGRAM						
LABOR GRADE 72				700 M/H	100 M/H	800 M/H
LABOR GRADE 74				5 020	780	5 800
LABOR GRADE 76				5 020	780	5 800
LABOR GRADE 78				1 400	200	1 600
LABOR GRADE 10				1 400	200	1 600
LABOR GRADE 06				700	100	800
SUB-TOTAL TASK 6.				14 240 M/H	2 160 M/H	16 400 M/H
TASK 7. MANAGEMENT						
LABOR GRADE 72	740 M/H	680 M/H	640 M/H	620 M/H	120 M/H	2 800 M/H
LABOR GRADE 74	3 660	3 560	3 400	3 280	500	14 400
LABOR GRADE 76	800	780	760	740	120	3 200
LABOR GRADE 78	800	780	760	740	120	3 200
LABOR GRADE 10	-	-	-	-	-	-0-
LABOR GRADE 06	720	680	640	620	140	2 800
SUB-TOTAL TASK 7.	6 720 M/H	6 480 M/H	6 200 M/H	6 000 M/H	1 000 M/H	26 400 M/H

FORM 49102 (8/67)

TABLE 4.8

MANHOUR ESTIMATE

BY LABOR GRADE, BY TASK, BY CALENDAR YEAR

PROPOSAL ACTION RESPONSE

DIRECT COST INPUT - DEPARTMENT ENGINEERING

PREP. BY: G. R. Miller DATE 1-10-80

APPROVED BY: H. R. Alexander 1-10-80

CAP: 7776R1 - ADVANCED COMPOSITE BLADES, HUBS AND NON-MECHANICAL CONTROLS FOR TILT ROTOR AIRCRAFT		CALENDAR 1981	CALENDAR 1982	CALENDAR 1983	CALENDAR 1984	CALENDAR 1985		TOTAL ENGINEERING MANHOURS
TOTAL PROGRAM SUMMARY								
LABOR GRADE 72		2 810 M/H	2 010 M/H	2 360 M/H	1 670 M/H	220 M/H		9 070 M/H
LABOR GRADE 74		14 600	10 760	11 060	9 660	1 280		47 360
LABOR GRADE 76		13 300	8 980	10 760	7 580	900		41 520
LABOR GRADE 78		10 580	7 420	10 400	3 860	320		32 580
LABOR GRADE 10		4 240	2 740	3 540	2 040	200		12 760
LABOR GRADE 06		2 790	2 010	2 360	1 670	240		9 070
TOTAL PROGRAMMING ENGINEERING		48 320 M/H	33 920 M/H	40 480 M/H	26 480 M/H	3 160 M/H		152 360 M/H

FORM 49102 (8/47)

TABLE 4.9 MANUFACTURING MANHOUR PLANNING ESTIMATES FOR XV15 ADVANCED BLADES-HUBS-FLY-BY-WIRE CONTROLS PROGRAM

TASK	ACTIVITY	DEV M/HRS ON SITE	DEV M/HRS OFF SITE	BLADES	INSTR. & CALIB.	BENCH TEST	TOOL DESIGN	TOOL FAB	MFG TECH	PLNG. & LIAISON	Q.C.	Q.A.	TOTAL
1	FAB (17) ROTOR BLADES	-	-	38,202	2,030	7,664	9,838	49,188	3,450	9,417	10,866	6,310	136,965
1	FAB (6) ROTOR BLADES (OPTION)	-	-	8,916	-	-	-	-	1,150	865	1,382	580	12,893
2	FAB (8) ROTOR HUB ASS'Y	52,497	-	-	-	6,605	1,053	4,211	2,000	6,141	9,135	4,115	85,757
2	FAB (2) ROTOR HUB ASS'Y (OPTION)	12,242	-	-	-	-	-	-	-	1,187	1,898	796	16,123
2	FAB (4) SPINNER ASS'Y	3,476	-	-	-	-	250	1,000	-	337	358	291	5,717
3	FLY BY WIRE (DEFINITION)	-	-	-	-	-	-	-	-	-	-	-	-
4	OPERATIONS/QUALIFICATION TESTS	14,954	-	-	-	-	-	-	-	1,450	1,495	972	18,871
4.1	NASA AMES WIND TUNNEL TEST	829	4,525	-	-	-	-	-	-	80	1,043	29	6,506
5.1	A/C FAMILIARIZATION COURSE	-	688	-	-	-	-	-	-	0	208	-	896
5.1	AIRCRAFT FAB/MOD/ASS'Y	12,131	-	-	-	-	-	-	-	1,177	1,213	789	15,310
5.2	FLY BY WIRE CONTROLS (DEFINITION)	-	-	-	-	-	-	-	-	-	-	-	-
5.3	REFURBISH R/H NACELLE PACKAGE	1,192	-	-	-	-	-	-	-	116	143	77	1,528
5.3	MODIFY L/H NACELLE PACKAGE	7,154	-	-	-	-	-	-	-	694	858	465	9,171
5.4/5.5	A/C TIE DOWN TEST (BOEING)	6,952	-	-	-	-	-	-	-	674	1,390	452	9,468
6	FLIGHT TEST (AMES)	-	10,392	-	-	-	-	-	-	0	1,888	-	12,280
6	A/C INSTRUMENTATION PACKAGE	-	-	-	4,000	-	-	-	-	388	480	260	5,128
5.2	SYSTEMS INTEGRATION TEST BENCH	2,700	-	-	-	-	-	-	-	262	216	176	3,354
1 & 2	Q.A. - R&D	-	-	-	-	-	-	-	-	-	-	300	300
	TOTAL	114,127	15,605	47,118	6,030	14,269	11,141	54,399	6,600	22,788	32,573	15,612	340,262

5.0 SUMMARY OF MATERIAL

TASK 1 - BLADES	QTY REQUIRED
Raw Material Blades	12 or 18
Raw Material Tool Proving Blades and Fatigue Speciments Specimens	5
Miscellaneous Material for Testing (Fixtures)	
Pins - Raw Materisl	24 or 36
Raw Material Pitch Shafts	12
Vendor Tooling: Design and Procurement - Instrumentation Strain Gages	81

TASK 2. HUBS — 8 or 10

	QTY REQUIRED PER HUB
Hub - 7075 Aluminum Forged Billet (3.25 thk. x 28.0 Dia.)	1
Rotor Shaft Adapter - 4340 Steel Forged Billet (9.50 x 8.0 L)	1
Hub Mount Plate - 4340 Steel Plate (.625 thk. x 9.00 Dia.)	1
Flexure Leaves - SP250-SF1 Fiberglass/Epoxy	(13.5 lbs)
Wear Sheets & Pads - Teflon Impregnated Dacron Cloth	(.02 thk x 2100 in^2)
Spherical Elastomeric Bearing - Parametrically Similar to Model 222 Cylindrical Elastomeric Bearing	3
Hub Reinforcement Shoe - 4340 Steel Plate (1.5 thk. x 4.5 x 10.0)	6
Yoke Fitting - 7075 Aluminum Plate (3.25 thk. x 7.0 x 10.0)	3
Leaf Clamp Pad - Silicone Rubber (.25 thk. x 1.75 x 3.0)	6

SUMMARY OF MATERIAL

TASK 2. HUB (CONTINUED)	QTY. REQUIRED PER HUB
Leaf Clamp Plate - 7075 Aluminum Plate (.20 thk. x 2.0 x 5.0)	6
Leaf Fitting - 17 - 4 Ph Stainless Steel Plate (1.50 thk. x 3.50 x 5.0)	3
Monoball Bearing - 1"	3
Monoball Bearing Mount Block - 7075 Aluminum Plate (2.0 thk. x 3.25 x 7.0)	3
Elastomeric Damper - Rubber (.60 thk. x 2.25 x 7.0)	6
Damper Fitting - 4340 Steel Plate (1.50 thk. x 5.75 x 7.50)	6
Yoke Clamp Plate - 4340 Steel Plate (.625 thk. x 3.0 x 7.0)	12
Yoke Beam - SP250-SFI Fiberglass/Epoxy (65 lb. total)	
Hub Mounting Hardware -	
- .50-20 UNJF x 3.75 Hex Head Bolt, High Strength Stnls. Steel	9
- .625 - 18 UNJF x 3.75 Hex Head Bolt, High Str. Stnls. Steel	3
- .50 Stnls. Stl. Fl. Washer	18
- .625 Stnls. Stl. Fl. Washer	6
- .50 Self Locking High Str. Stnls. Steel Nut	9
- .625 Stnls. St. Shigh Str. Self-Locking Nut	3
Spherical Elast. Brg. Mtg. Hardware	
- .50-20 UNJF x 3.75 Hx. Hd. Bolt, High Str. Stnls. Stl.	12
- .50 Stnls. Stl. Fl. Washer	24
- .50 Stnls. St. Self-Lkg. Nut High Str.	12
- 1.00 Stnls. Stl. Self-Locking Nut	3

SUMMARY OF MATERIAL

TASK 2. HUB (CONTINUED)	QTY. REQUIRED PER HUB
Leaf Clamp Hardware	
- .50 - 20 UNJF x 2.25 Hx. Hd. Bolt High Str. Stnls. Stl.	6
- .50 Stnls. Stl. Fl. Washer	12
- .50 Stnls. Stl. Self-Locking Nut	6
Inboard Beam Attachment Hardware	
- Pin - 4340 Steel Bar (2.00 Dia. x 14.0)	6
- Washer - 1.00 Dia. Stnls. Stl.	6
- Nut - Self-Locking - High Str. Stnls. Stl. 1.00 - 12 UNJF	6
Blade Attachment Hardware	
- Pin - 4340 Steel Bar (2.00 Dia. x 8.25)	6
- Washer - 1.00 Stnls. Steel	12
- Nut - Self-Locking High Str. Stnls. Stl. (1.00 - 12 UNJF)	6
Pitch Arm - 7075 Aluminum Forged Billet (4.50 x 6.00 x 14.00)	3
Bushing - 15-5 PH Stnls. Stl. Bar (.75 Dia. x 2.00)	21
Bushing 15-5 PH Stnls. Stl. Bar (1.00 Dia. x 2.00)	3
Bushing - 15-5 PH Stnls. Stl. Bar (1.50 Dia. x 1.50)	24
TASK 3. FLY-BY-WIRE CONTROLS	
Vendor Design & Engineering DELS Unit	
Vendor Flight-Worthiness Tests	
Vendor Field Support	
Computer Control Unit	1
1 Set Spares	
Test Unit	1

SUMMARY OF MATERIAL

TASK 3. FLY-BY-WIRE CONTROLS (CONTINUED)	QTY. REQUIRED
Wind Tunnel Controller	1
Design/Engine Actuators	
Flight Qualification	
Field Support	
Actuators	17

TASK 4. OPERATIONAL/QUALIFICATION TESTS

Miscellaneous Rigs/Instruments, etc.		
Telemetry Equipment		
Torquemeter System		
Accelerometers:	2262-25	5
	2271/29941	10
	Q Flex	4
Slip Rings		6
Fuel Estimated 30,000 gal.		
Miscellaneous Oil - Hydraulic Fluid		

TASK 5. XV-15 MODIFICATION

Mounting for Actuators (Materials Estimate)

Cockpit Modifications for Fly-by-Wire (Materials Estimate)

Installation of Flight Control Runs (Materials Estimate)

Aircraft Rigging/Static/Functional Tests

TASK 6. FLIGHT TEST

No material. Aircraft Spares in addition to those procured herein are assumed GFE.

6.0 FINANCIAL AND PRICING INFORMATION

Planning price data is summarized in Table 6.0 for the baseline program and option considered (i.e. 17 blades, 8 hubs and 23 blades, 10 hubs).

Prices are given in constant calendar year 1980 dollars. The baseline price is $31,779,000 and the option price is $33,312,000.

Table 6.1 Sheet 1 gives breakdown of total program price in terms of Direct Costs, Overhead Costs and Profit. A 10% fee is assumed. Subcontract costs include costs of fly-by-wire computers, actuators and vendor support.

Table 6.1 Sheets 2 through 9 give similar breakdown by individual task.

Table 6.2 Sheets 1 through 9 give the corresponding pricing information for the program option for 23 blades and 10 hubs.

Table 6.3 gives summary of Material Planning Cost Estimates which are based on prior CH46, CH47 experience where appropriate. A detailed breakdown is presented in the case of Task 3 because this includes major cost elements associated with Subcontract vendor engineering and design support and procurement of the flight control processor and actuator units: These details are given in Table 6.3.1.

TABLE 6.0 SUMMARY OF PLANNINC PRICE DATA

Preliminary Design Studes of Advance Composite
Blades, Hubs, and Nonmechanical Controls
for the Tilt Rotor Aircraft

Task	Baseline (17 Blades 8 Hubs)	Option (23 Blades 10 Hubs)
1	$ 7,536,000	$ 8,225,000
2	5,711,000	6,555,000
3	10,216,000	10,216,000
4	1,506,000	1,506,000
4.1	832,000	832,000
5	2,787,000	2,787,000
6	1,784,000	1,784,000
7	$ 1,407,000	$ 1,407,000
TOTAL	$31,779,000	$33,312,000

6.1 Baseline Program Financial and Pricing Planning Data

Table 6.1 Sheets 1 through 9 gives financial and pricing data for the baseline program which envisions fabrication of 17 blades and 8 hubs (including structural test and proof of tooling specimens).

COST AND/OR PRICE SUMMARY DATE [illegible] BASELINE

RFE7776 NASA2 10160 PLANNING PRICE TOTAL PROGRAM (CY 80$)

TABLE 6.1
Sheet 1 of 9

	ON-SITE	OFF-SITE	TOTAL
LABOR HOURS			
ENGINEERING	137406	14960	152366
PRODUCT SUPPORT			
DEVELOPMENTAL	160386	15605	175991
MFG TECH	6698		6698
TOOL DESIGN	11141		11141
TOOL FAB	54399		54399
PRODUCTION			
PLAN & LIAISON	20736		20736
PROD SERVICES	38493		38493
TOOL SERVICES	9666		9666
QUALITY ASSURANCE	14236		14236
QUALITY CONTROL	26246	3047	29293
DIRECT LABOR DOLLARS			
ENGINEERING	2123227	253246	2376475
PROD SUPPORT			
* SUB-TOT-ENGR *	2123227	253248	2376475
DEVELOPMENTAL	1688864	164321	1853185
MFG TECH	95370		95370
TOOL DESIGN	121326		121326
TOOL FAB	555957		555957
PRODUCTION			
PLAN & LIAISON	[illegible]		[illegible]
PROD SERVICES	359910		359910
TOOL SERVICES	94436		94436
QUALITY ASSUR	154033		154033
QUALITY CONTROL	276895	32145	309040
* SUB-TOT-MFG *	3552493	196466	3748959
MATERIAL DOLLARS			
DEVEL MATL	933304		933304
TOOL MATL			
SUB-TOOLING			
PROD MATL			
OUTSIDE PROD			
* SUB-TOT-MATL *	933304		933304
OTHER DIRECT COST			
SUBCONT	6687124		6687124
TRAVEL	748574		748574
FRINGE BENEFITS	2724346	215863	2940209
OVERHEAD DOLLARS			
ENGRG OHD	1868440	37988	1906428
MFG OHD	4973489	29470	5002959
MATL OHD			
ADM BASE	[illegible]	[illegible]	[illegible]
ADM EXPENSE	2358520	76235	2434755
G AND A BASE	25036593	809270	25845863
G&A EXPENSE	1677452	54221	1731673
OTHER COSTS			
IDWA			
GFAE TYPE MATL			
PACKAGING			
P.L.I.			
TOTAL COST	27647349	863451	28510800
PROFIT	2764734	86349	2851083
FCCM INPLANT	391434	25955	417389
FCCM OUTPLANT			
SALES PRICE	30803517	975795	31779312

COST AND/OR PRICE SUMMARY DATE [illegible] BASELINE

RFE 7776 NAS8 10160 PLANNING PRICE TASK 1 (CY 80$)

Table 6.1
Sheet 2 of 9

	ON-SITE	OFF-SITE	TOTAL
LABOR HOURS			
ENGINEERING	[illegible]		[illegible]
PRODUCT SUPPORT			
DEVELOPMENTAL	47896		47896
MFG TECH	[illegible]		[illegible]
TOOL DESIGN	9838		9838
TOOL FAB	49188		49188
PRODUCTION			
PLAN & LIAISON	9417		9417
PROD SERVICES	11495		11495
TOOL SERVICES	4369		4369
QUALITY ASSURANCE	6510		6510
QUALITY CONTROL	10866		10866
DIRECT LABOR DOLLARS			
ENGINEERING	302987		302987
PROD SUPPORT			
* SUB-TOT-ENGR *	302987		302987
DEVELOPMENTAL	504345		504345
MFG TECH	66470		66470
TOOL DESIGN	107136		107136
TOOL FAB	502701		502701
PRODUCTION			
PLAN & LIAISON	93417		93417
PROD SERVICES	107478		107478
TOOL SERVICES	42685		42685
QUALITY ASSUR	70438		70438
QUALITY CONTROL	114636		114636
* SUB-TOT-MFG *	1609306		1609306
MATERIAL DOLLARS			
DEVEL MATL	417384		417384
TOOL MATL			
SUB-TOOLING			
PROD MATL			
OUTSIDE PROD			
* SUB-TOT-MATL *	417384		417384
OTHER DIRECT COST			
TRAVEL	2314		2314
FRINGE BENEFITS	[illegible]		[illegible]
OVERHEAD DOLLARS			
ENGRG OHD	266629		266629
MFG OHD	[illegible]		[illegible]
MATL OHD			
ADM BASE	5352165		5352165
ADM EXPENSE	556625		556625
G AND A BASE	5908790		5908790
G&A EXPENSE	395889		395889
OTHER COSTS			
IDWA			
GFAE TYPE MATL			
PACKAGING			
P.L.I.			
TOTAL COST	6722063		6722063
PROFIT	[illegible]		[illegible]
FCCM INPLANT	142005		142005
FCCM OUTPLANT			
SALES PRICE	[illegible]		[illegible]

COST AND/OR PRICE SUMMARY DATE [illegible] BASELINE

RFE 7776 NASA2-19160 PLANNING PRICE TASK 2(CY [illegible])

Table 6.1
Sheet 3 of 9

	ON-SITE	OFF-SITE	TOTAL
LABOR HOURS			
ENGINEERING	21760		21760
PRODUCT SUPPORT			
DEVELOPMENTAL	62578		62578
MFG TECH	[illegible]		[illegible]
TOOL DESIGN	1303		1303
TOOL FAB	5211		5211
PRODUCTION			
PLAN & LIAISON	6478		6478
PROD SERVICES	15019		15019
TOOL SERVICES	[illegible]		[illegible]
QUALITY ASSURANCE	4506		4506
QUALITY CONTROL	9493		9493
DIRECT LABOR DOLLARS			
ENGINEERING	332941		332941
PROD SUPPORT			
* SUB-TOT-ENGG *	332941		332941
DEVELOPMENTAL	658946		658946
MFG TECH	28900		28900
TOOL DESIGN	[illegible]		[illegible]
TOOL FAB	53256		53256
PRODUCTION			
PLAN & LIAISON	64262		64262
PROD SERVICES	140428		140428
TOOL SERVICES	29808		29808
QUALITY ASSUR	46755		46755
QUALITY CONTROL	100151		100151
* SUB-TOT-MFG *	1138696		1138696
MATERIAL DOLLARS			
DEVEL MATL	295300		295300
TOOL MATL			
SUB-TOOLING			
PROD MATL			
OUTSIDE PROC			
* SUB-TOT-MATL *	295300		295300
OTHER DIRECT COST			
TRAVEL	10235		10235
FRINGE BENEFITS	[illegible]		[illegible]
OVERHEAD DOLLARS			
ENGRG OHD	292988		292988
MFG OHD	[illegible]		[illegible]
MATL OHD			
ADM BASE	4075420		4075420
ADM EXPENSE	[illegible]		[illegible]
G AND A BASE	4499264		4499264
G&A EXPENSE	301451		301451
OTHER COSTS			
IDWA			
GFAE TYPE MATL			
PACKAGING			
P.L.I.			
TOTAL COST	5096015		5096015
PROFIT	[illegible]		[illegible]
FCCM INPLANT	105677		105677
FCCM OUTPLANT			
SALES PRICE	[illegible]		[illegible]

COST AND/OR PRICE SUMMARY DATE [illegible] BASELINE

RFE 7776 NASA2 10160 PLANNING PRICE TASK 3 (CY 80$)

Table 6.1
Sheet 4 of 9

	ON-SITE	OFF-SITE	TOTAL
LABOR HOURS			
ENGINEERING	3,286		[illegible]
PRODUCT SUPPORT			
DEVELOPMENTAL	0		0
MFG TECH	0		0
TOOL DESIGN	0		0
TOOL FAB	0		0
PRODUCTION			
PLAN & LIAISON	0		0
PROD SERVICES			
TOOL SERVICES			
QUALITY ASSURANCE	0		0
QUALITY CONTROL	0		0
DIRECT LABOR DOLLARS			
ENGINEERING	465097		465097
PROD SUPPORT			
* SUB-TOT-ENGR *	465097		465097
DEVELOPMENTAL			
MFG TECH			
TOOL DESIGN			
TOOL FAB			
PRODUCTION			
PLAN & LIAISON			
PROD SERVICES			
TOOL SERVICES			
QUALITY ASSUR			
QUALITY CONTROL			
* SUB-TOT-MFG *			
MATERIAL DOLLARS			
DEVEL MATL			
TOOL MATL			
SUB-TOOLING			
PROD MATL			
OUTSIDE PROD			
* SUB-TOT-MATL *			
OTHER DIRECT COST			
SUBCONT	6687104		6687104
TRAVEL	73505		73505
FRINGE BENEFITS	223247		223247
OVERHEAD DOLLARS			
ENGRG OHD	409285		409285
MFG OHD			
MATL OHD			
ADM BASE	7858238		7858238
ADM EXPENSE	817257		817257
G AND A BASE	8675495		8675495
G&A EXPENSE	581258		581258
OTHER COSTS			
IDWA			
GFAE TYPE MATL			
PACKAGING			
P.L.I.			
TOTAL COST	9256753		9256753
PROFIT	925675		925675
FCCM INPLANT	33422		33422
FCCM OUTPLANT			
SALES PRICE	10215850		10215850

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COST AND/OR PRICE SUMMARY DATE [illegible] BASELINE

RFE 7776 NASA2 1.16? PLANNING PRICE TASK 4 (CY 80$)

Table 6.1
Sheet 5 of 9

	ON-SITE	OFF-SITE	TOTAL
LABOR HOURS			
ENGINEERING	[illegible]		[illegible]
PRODUCT SUPPORT			
DEVELOPMENTAL	14954		14954
MFG TECH	0		0
TOOL DESIGN	0		0
TOOL FAB	0		0
PRODUCTION			
PLAN & LIAISON	1450		1450
PROD SERVICES	3589		3589
TOOL SERVICES	673		673
QUALITY ASSURANCE	972		972
QUALITY CONTROL	1495		1495
DIRECT LABOR DOLLARS			
ENGINEERING	130665		130665
PROD SUPPORT			
* SUB-TOT-ENGR *	130665		130665
DEVELOPMENTAL	157466		157466
MFG TECH			
TOOL DESIGN			
TOOL FAB			
PRODUCTION			
PLAN & LIAISON	14384		14384
PROD SERVICES	33557		33557
TOOL SERVICES	6575		6575
QUALITY ASSUR	10517		10517
QUALITY CONTROL	15772		15772
* SUB-TOT-MFG *	238271		238271
MATERIAL DOLLARS			
DEVEL MATL	174800		174800
TOOL MATL			
SUB-TOOLING			
PROD MATL			
OUTSIDE PROD			
* SUB-TOT-MATL *	174800		174800
OTHER DIRECT COST			
FRINGE BENEFITS	177089		177089
OVERHEAD DOLLARS			
ENGRG OHD	114985		114985
MFG OHD	333579		333579
MATL OHD			
ADM BASE	994589		994589
ADM EXPENSE	103437		103437
G AND A BASE	[illegible]		[illegible]
G&A EXPENSE	73568		73568
OTHER COSTS			
IDWA			
GFAE TYPE MATL			
PACKAGING			
P.L.I.			
TOTAL COST	1346394		1346394
PROFIT	134639		134639
FCCM INPLANT	24775		24775
FCCM OUTPLANT			
SALES PRICE	1505808		1505808

COST AND/OR PRICE SUMMARY DATE [illegible] BASELINE

RFE7776 NASA2 10160 PLANNING PRICE TASK 4.1 (CY [illegible])

Table 6.1
Sheet 6 of 9

	ON-SITE	OFF-SITE	TOTAL
LABOR HOURS			
ENGINEERING	[illegible]	[illegible]	[illegible]
PRODUCT SUPPORT			
DEVELOPMENTAL	829	4525	5354
MFG TECH	[illegible]		[illegible]
TOOL DESIGN	0		0
TOOL FAB	0		0
PRODUCTION			
PLAN & LIAISON	80		80
PROD SERVICES	199		199
TOOL SERVICES	37		37
QUALITY ASSURANCE	29		29
QUALITY CONTROL	92	951	1043
DIRECT LABOR DOLLARS			
ENGINEERING	153758	21125	174883
PROD SUPPORT			
* SUB-TOT-ENGR *	153758	21125	174883
DEVELOPMENTAL	8729	47648	56377
MFG TECH			
TOOL DESIGN			
TOOL FAB			
PRODUCTION			
PLAN & LIAISON	754		754
PROD SERVICES	1861		1861
TOOL SERVICES	361		361
QUALITY ASSUR	314		314
QUALITY CONTROL	971	10033	11004
* SUB-TOT-MFG *	13030	57681	70711
MATERIAL DOLLARS			
DEVEL MATL			
TOOL MATL			
SUB-TOOLING			
PROD MATL			
OUTSIDE PROD			
* SUB-TOT-MATL *			
OTHER DIRECT COST			
TRAVEL	103331		103331
FRINGE BENEFITS	80058	37627	117685
OVERHEAD DOLLARS			
ENGRG OHD	135307	3169	138476
MFG OHD	18242	8652	26894
MATL OHD			
ADM BASE	503726	128454	632180
ADM EXPENSE	52388	13359	65747
G AND A BASE	556114	141813	697927
G&A EXPENSE	37260	9501	46761
OTHER COSTS			
IDWA			
GFAE TYPE MATL			
PACKAGING			
P.L.I.			
TOTAL COST	593374	151314	744688
PROFIT	59337	15131	74468
FCCM INPLANT	7964	5369	13333
FCCM OUTPLANT			
SALES PRICE	660675	171814	832489

COST AND/OR PRICE SUMMARY DATE [illegible] BASELINE

RFE 7776 NASA2 10160 PLANNING PRICE TASK 5 (CY 80$)

Table 6.1
Sheet 7 of 9

	ON-SITE	OFF-SITE	TOTAL
LABOR HOURS			
ENGINEERING	1164[illegible]	576[illegible]	174[illegible]
PRODUCT SUPPORT			
DEVELOPMENTAL	30129	688	30817
MFG TECH	0		0
TOOL DESIGN	0		0
TOOL FAB	0		0
PRODUCTION			
PLAN & LIAISON	2923		2923
PROD SERVICES	7231		7231
TOOL SERVICES	1356		1356
QUALITY ASSURANCE	1959		1959
QUALITY CONTROL	3620	208	4028
DIRECT LABOR DOLLARS			
ENGINEERING	166310	95888	262198
PROD SUPPORT			
* SUB-TOT-ENGG *	166310	95888	262198
DEVELOPMENTAL	317258	7245	324503
MFG TECH			
TOOL DESIGN			
TOOL FAB			
PRODUCTION			
PLAN & LIAISON	28596		28596
PROD SERVICES	67610		67610
TOOL SERVICES	13248		13248
QUALITY ASSUR	21196		21196
QUALITY CONTROL	40301	2194	42495
* SUB-TOT-MFG *	488609	9439	498048
MATERIAL DOLLARS			
DEVEL MATL	45820		45820
TOOL MATL			
SUB-TOOLING			
PROD MATL			
OUTSIDE PROD			
* SUB-TOT-MATL *	45820		45820
OTHER DIRECT COST			
TRAVEL	1[illegible]		1[illegible]
FRINGE BENEFITS	314361	5[illegible]557	364[illegible]
OVERHEAD DOLLARS			
ENGRG OHD	146353	14383	160736
MFG OHD	684[illegible]53	1416	6854[illegible]
MATL OHD			
ADM BASE	1900686	171683	2072369
ADM EXPENSE	197671	17855	215526
G AND A BASE	2098357	189538	2287895
G&A EXPENSE	140590	12699	153289
OTHER COSTS			
IDWA			
GFAE TYPE MATL			
PACKAGING			
P.L.I.			
TOTAL COST	2284767	202237	2487004
PROFIT	228477	[illegible]	[illegible]
FCCM INPLANT	46557	4788	51345
FCCM OUTPLANT			
SALES PRICE	[illegible]	[illegible]	[illegible]

COST AND/OR PRICE SUMMARY DATE [illegible] BASELINE

RFE7776 NASA2 10160 PLANNING PRICE TASK 6 (CY 80$)

Table 6.1
Sheet 8 of 9

	ON-SITE	OFF-SITE	TOTAL
LABOR HOURS			
ENGINEERING	[illegible]	6480	[illegible]
PRODUCT SUPPORT			
DEVELOPMENTAL	4000	10392	14392
MFG TECH	[illegible]		[illegible]
TOOL DESIGN	0		0
TOOL FAB	0		0
PRODUCTION			
PLAN & LIAISON	388		388
PROD SERVICES	960		960
TOOL SERVICES	160		160
QUALITY ASSURANCE	260		260
QUALITY CONTROL	480	1888	2368
DIRECT LABOR DOLLARS			
ENGINEERING	149878	111510	261388
PROD SUPPORT			
* SUB-TOT-ENGR *	149878	111510	261388
DEVELOPMENTAL	42120	109428	151546
MFG TECH			
TOOL DESIGN			
TOOL FAB			
PRODUCTION			
PLAN & LIAISON	[illegible]		[illegible]
PROD SERVICES	8976		8976
TOOL SERVICES	1759		1759
QUALITY ASSUR	2813		2813
QUALITY CONTROL	5064	19918	24982
* SUB-TOT-MFG *	64581	129346	193927
MATERIAL DOLLARS			
DEVEL MATL			
TOOL MATL			
SUB-TOOLING			
PROD MATL			
OUTSIDE PROD			
* SUB-TOT-MATL *			
OTHER DIRECT COST			
TRAVEL	423056		423056
FRINGE BENEFITS	[illegible]	115611	[illegible]
OVERHEAD DOLLARS			
ENGRG OHD	131893	16727	148620
MFG OHD	90413	19402	109815
MATL OHD			
ADM BASE	962761	392596	1355357
ADM EXPENSE	[illegible]	[illegible]	[illegible]
G AND A BASE	1062888	433426	1496314
G&A EXPENSE	71213	29040	100253
OTHER COSTS			
IDWA			
GFAE TYPE MATL			
PACKAGING			
P.L.I.			
TOTAL COST	1134101	462466	1596567
PROFIT	[illegible]	46247	159657
FCCM INPLANT	12537	14752	27289
FCCM OUTPLANT			
SALES PRICE	[illegible]	523465	[illegible]

COST AND/OR PRICE SUMMARY DATE [illegible] BASELINE

RFE7776 NASA2 1016[illegible] PLANNING PRICE TASK 7 (CY 8[illegible]$)

Table 6.1
Sheet 9 of 9

	ON-SITE	OFF-SITE	TOTAL
LABOR HOURS			
ENGINEERING	[illegible]	[illegible]	[illegible]
PRODUCT SUPPORT			
DEVELOPMENTAL	0		0
MFG TECH	0		0
TOOL DESIGN	0		0
TOOL FAB	0		0
PRODUCTION			
PLAN & LIAISON	0		0
PROD SERVICES			
TOOL SERVICES			
QUALITY ASSURANCE	0		0
QUALITY CONTROL	0		0
DIRECT LABOR DOLLARS			
ENGINEERING	421591	24725	446316
PROD SUPPORT			
* SUB-TOT-ENGR *	421591	24725	446316
DEVELOPMENTAL			
MFG TECH			
TOOL DESIGN			
TOOL FAB			
PRODUCTION			
PLAN & LIAISON			
PROD SERVICES			
TOOL SERVICES			
QUALITY ASSUR			
QUALITY CONTROL			
* SUB-TOT-MFG *			
MATERIAL DOLLARS			
DEVEL MATL			
TOOL MATL			
SUB-TOOLING			
PROD MATL			
OUTSIDE PROD			
* SUB-TOT-MATL *			
OTHER DIRECT COST			
TRAVEL	35533		35533
FRINGE BENEFITS	202364	[illegible]	214232
OVERHEAD DOLLARS			
ENGRG OHD	371030	3709	374739
MFG OHD			
MATL OHD			
ADM BASE	1030488	40302	1070790
ADM EXPENSE	107171	4191	111362
G AND A BASE	1137659	44493	1182152
G&A EXPENSE	76223	2981	79204
OTHER COSTS			
IDWA			
GFAE TYPE MATL			
PACKAGING			
P.L.I.			
TOTAL COST	1213882	47474	1261356
PROFIT	121388	4747	126135
FCCM INPLANT	18497	1046	19543
FCCM OUTPLANT			
SALES PRICE	1353767	53267	14[illegible]7034

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COST AND/OR PRICE SUMMARY   DATE 02/15/80   OPTION

RFE7776 NASA2 10160 PLANNING PRICE TOTAL PROGRAM (CY 80$)

Table 6.2
Sheet 1 of 9

	ON-SITE	OFF-SITE	TOTAL
LABOR HOURS			
ENGINEERING	137400	14960	152360
PRODUCT SUPPORT			
DEVELOPMENTAL	181544	15605	197149
MFG TECH	6600		6600
TOOL DESIGN	11141		11141
TOOL FAB	54399		54399
PRODUCTION			
PLAN & LIAISON	22788		22788
PROD SERVICES	43571		43571
TOOL SERVICES	10617		10617
QUALITY ASSURANCE	15612		15612
QUALITY CONTROL	29526	3047	32573
DIRECT LABOR DOLLARS			
ENGINEERING	2123227	253248	2376475
PROD SUPPORT			
* SUB-TOT-ENGR *	2123227	253248	2376475
DEVELOPMENTAL	1911658	164321	2075979
MFG TECH	95370		95370
TOOL DESIGN	121326		121326
TOOL FAB	555957		555957
PRODUCTION			
PLAN & LIAISON	226057		226057
PROD SERVICES	407389		407389
TOOL SERVICES	103728		103728
QUALITY ASSUR	168922		168922
QUALITY CONTROL	311499	32145	343644
* SUB-TOT-MFG *	3901906	196466	4098372
MATERIAL DOLLARS			
DEVEL MATL	1114946		1114946
TOOL MATL			
SUB-TOOLING			
PROD MATL			
OUTSIDE PROD			
* SUB-TOT-MATL *	1114946		1114946
OTHER DIRECT COST			
SUBCONT	6687104		6687104
TRAVEL	746974		746974
FRINGE BENEFITS	2892064	215863	3107927
OVERHEAD DOLLARS			
ENGRG OHD	1868440	37989	1906429
MFG OHD	5462668	29470	5492138
MATL OHD			
ADM BASE	23684783	733035	24417818
ADM EXPENSE	2463176	76235	2539411
G AND A BASE	26147959	809270	2695682[illegible]
G&A EXPENSE	1751886	54221	1806107
OTHER COSTS			
IDWA			
GFAE TYPE MATL			
PACKAGING			
P.L.I.			
TOTAL COST	29014391	863491	29877882
PROFIT	2901435	86349	2987787
FCCM INPLANT	419389	25955	445343
FCCM OUTPLANT			
SALES PRICE	32335217	975795	33311012

COST AND/OR PRICE SUMMARY DATE 02/15/80 OPTION

REF 7776 NASA? 10160 PLANNING PRICE TASK 1 (CY 80$)

Table 6.2
Sheet 2 of 9

	ON-SITE	OFF-SITE	TOTAL
LABOR HOURS			
ENGINEERING	19900		19900
PRODUCT SUPPORT			
DEVELOPMENTAL	56612		56612
MFG TECH	4600		4600
TOOL DESIGN	9938		9938
TOOL FAB	49188		49188
PRODUCTION			
PLAN & LIAISON	10282		10282
PROD SERVICES	13635		13635
TOOL SERVICES	4770		4770
QUALITY ASSURANCE	7090		7090
QUALITY CONTROL	12248		12248
DIRECT LABOR DOLLARS			
ENGINEERING	302987		302987
PROD SUPPORT			
* SUB-TOT-ENGR *	302987		302987
DEVELOPMENTAL	598230		598230
MFG TECH	66470		66470
TOOL DESIGN	107136		107136
TOOL FAB	502701		502701
PRODUCTION			
PLAN & LIAISON	101997		101997
PROD SERVICES	127487		127487
TOOL SERVICES	46603		46603
QUALITY ASSUR	76714		76714
QUALITY CONTROL	129216		129216
* SUB-TOT-MFG *	1756554		1756554
MATERIAL DOLLARS			
DEVEL MATL	532824		532824
TOOL MATL			
SUB-TOOLING			
PROD MATL			
OUTSIDE PROD			
* SUB-TOT-MATL *	532824		532824
OTHER DIRECT COST			
TRAVEL	2314		2314
FRINGE BENEFITS	568580		568580
OVERHEAD DOLLARS			
ENGRG OHD	266629		266629
MFG OHD	2459176		2459176
MATL OHD			
ADM BASE	5776240		5776240
ADM EXPENSE	600729		600729
G AND A BASE	6376969		6376969
G&A EXPENSE	427257		427257
OTHER COSTS			
IDWA			
GFAE TYPE MATL			
PACKAGING			
P.L.T.			
TOTAL COST	7337050		7337050
PROFIT	733705		733705
FCCM INPLANT	153785		153785
FCCM OUTPLANT			
SALES PRICE	8224540		8224540

COST AND/OR PRICE SUMMARY   DATE 02/15/80   OPTION

RFE 7776 NAS12-19160 PLANNING PRICE TASK 2(CY 80$)

Table 6.2
Sheet 3 of 9

	ON-SITE	OFF-SITE	TOTAL
LABOR HOURS			
ENGINEERING	21700		21700
PRODUCT SUPPORT			
DEVELOPMENTAL	74820		74820
MFG TECH	2000		2000
TOOL DESIGN	1303		1303
TOOL FAB	5211		5211
PRODUCTION			
PLAN & LIAISON	7665		7665
PROD SERVICES	17957		17957
TOOL SERVICES	3601		3601
QUALITY ASSURANCE	5702		5702
QUALITY CONTROL	11391		11391
DIRECT LABOR DOLLARS			
ENGINEERING	332941		332941
PROD SUPPORT			
* SUB-TOT-ENGR *	332941		332941
DEVELOPMENTAL	767955		767955
MFG TECH	28900		28900
TOOL DESIGN	14190		14190
TOOL FAB	53256		53256
PRODUCTION			
PLAN & LIAISON	76037		76037
PROD SERVICES	167955		167955
TOOL SERVICES	35182		35182
QUALITY ASSUR	57368		57368
QUALITY CONTROL	120175		120175
* SUB-TOT-MFG *	1340861		1340861
MATERIAL DOLLARS			
DEVEL MATL	361502		361502
TOOL MATL			
SUB-TOOLING			
PROD MATL			
OUTSIDE PROD			
* SUB-TOT-MATL *	361502		361502
OTHER DIRECT COST			
TRAVEL	10235		10235
FRINGE BENEFITS	803425		803425
OVERHEAD DOLLARS			
ENGRG OHD	292988		292988
MFG OHD	1677205		1677205
MATL OHD			
ADM BASE	4657655		4657655
ADM EXPENSE	484396		484396
G AND A BASE	5142051		5142051
G&A EXPENSE	344517		344517
OTHER COSTS			
IDWA			
GFAE TYPE MATL			
PACKAGING			
P.L.T.			
TOTAL COST	5848070		5848070
PROFIT	584807		584807
FCCM INPLANT	121851		121851
FCCM OUTPLANT			
SALES PRICE	6554728		6554728

COST AND/OR PRICE SUMMARY DATE 02/15/80 OPTION

REF 7776 [illegible] 10160 PLANNING PRICE TASK 3 (BY [illegible])

Table 6.2
Sheet 4 of 9

	ON-SITE	OFF-SITE	TOTAL
LABOR HOURS			
ENGINEERING	30280		30280
PRODUCT SUPPORT			
DEVELOPMENTAL	0		0
MFG TECH	0		0
TOOL DESIGN	0		0
TOOL FAB	0		0
PRODUCTION			
PLAN & LIAISON	0		0
PROD SERVICES			
TOOL SERVICES			
QUALITY ASSURANCE	0		0
QUALITY CONTROL	0		0
DIRECT LABOR DOLLARS			
ENGINEERING	465097		465097
PROD SUPPORT			
* SUB-TOT-ENGR *	465097		465097
DEVELOPMENTAL			
MFG TECH			
TOOL DESIGN			
TOOL FAB			
PRODUCTION			
PLAN & LIAISON			
PROD SERVICES			
TOOL SERVICES			
QUALITY ASSUR			
QUALITY CONTROL			
* SUB-TOT-MFG *			
MATERIAL DOLLARS			
DEVEL MATL			
TOOL MATL			
SUB-TOOLING			
PROD MATL			
OUTSIDE PROD			
* SUB-TOT-MATL *			
OTHER DIRECT COST			
SUBCONT	6687104		6687104
TRAVEL	73505		73505
FRINGE BENEFITS	223247		223247
OVERHEAD DOLLARS			
ENGRG OHD	409285		409285
MFG OHD			
MATL OHD			
ADM BASE	7858238		7858238
ADM EXPENSE	817257		817257
G AND A BASE	8675495		8675495
G&A EXPENSE	581258		581258
OTHER COSTS			
IDWA			
GFAE TYPE MATL			
PACKAGING			
F.L.T.			
TOTAL COST	9256753		9256753
PROFIT	925675		925675
FCCM INPLANT	33422		33422
FCCM OUTPLANT			
SALES PRICE	10215850		10215850

COST AND/OR PRICE SUMMARY DATE 02/15/80 OPTION

REF 7776 NAS8 10169 PLANNING PRICE TASK 4 (CY 80$)

Table 6.2
Sheet 5 of 9

	ON-SITE	OFF-SITE	TOTAL
LABOR HOURS			
ENGINEERING	8680		8680
PRODUCT SUPPORT			
DEVELOPMENTAL	14954		14954
MFG TECH	0		0
TOOL DESIGN	0		0
TOOL FAB	0		0
PRODUCTION			
PLAN & LIAISON	1450		1450
PROD SERVICES	3569		3569
TOOL SERVICES	673		673
QUALITY ASSURANCE	972		972
QUALITY CONTROL	1495		1495
DIRECT LABOR DOLLARS			
ENGINEERING	130665		130665
PROD SUPPORT			
* SUB-TOT-ENGR *	130665		130665
DEVELOPMENTAL	157466		157466
MFG TECH			
TOOL DESIGN			
TOOL FAB			
PRODUCTION			
PLAN & LIAISON	14384		14384
PROD SERVICES	33557		33557
TOOL SERVICES	6575		6575
QUALITY ASSUR	10517		10517
QUALITY CONTROL	15772		15772
* SUB-TOT-MFG *	238271		238271
MATERIAL DOLLARS			
DEVEL MATL	174800		174800
TOOL MATL			
SUB-TOOLING			
PROD MATL			
OUTSIDE PROD			
* SUB-TOT-MATL *	174800		174800
OTHER DIRECT COST			
FRINGE BENEFITS	177089		177089
OVERHEAD DOLLARS			
ENGRG OHD	114985		114985
MFG OHD	333575		333575
MATL OHD			
ADM BASE	994585		994585
ADM EXPENSE	103437		103437
G AND A BASE	1098026		1098026
G&A EXPENSE	73568		73568
OTHER COSTS			
IDWA			
GFAE TYPE MATL			
PACKAGING			
P.L.I.			
TOTAL COST	1346394		1346394
PROFIT	134639		134639
FCCM INPLANT	24775		24775
FCCM OUTPLANT			
SALES PRICE	1505808		1505808

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COST AND/OR PRICE SUMMARY DATE 02/15/80 OPTION

REF7776 NASA2 10160 PLANNING PRICE TASK 4.1 (CY [illegible])

Table 6.2
Sheet 6 of 9

	ON-SITE	OFF-SITE	TOTAL
LABOR HOURS			
ENGINEERING	10320	1280	11600
PRODUCT SUPPORT			
DEVELOPMENTAL	829	4525	5354
MFG TECH	0		0
TOOL DESIGN	0		0
TOOL FAB	0		0
PRODUCTION			
PLAN & LIAISON	80		80
PROD SERVICES	199		199
TOOL SERVICES	37		37
QUALITY ASSURANCE	29		29
QUALITY CONTROL	92	951	1043
DIRECT LABOR DOLLARS			
ENGINEERING	153758	21125	174883
PROD SUPPORT			
* SUB-TOT-ENGR *	153758	21125	174883
DEVELOPMENTAL	8729	47648	56377
MFG TECH			
TOOL DESIGN			
TOOL FAB			
PRODUCTION			
PLAN & LIAISON	794		794
PROD SERVICES	1961		1961
TOOL SERVICES	361		361
QUALITY ASSUR	314		314
QUALITY CONTROL	971	10033	11004
* SUB-TOT-MFG *	13030	57681	70711
MATERIAL DOLLARS			
DEVEL MATL			
TOOL MATL			
SUB-TOOLING			
PROD MATL			
OUTSIDE PROC			
* SUB-TOT-MATL *			
OTHER DIRECT COST			
TRAVEL	103331		103331
FRINGE BENEFITS	80058	37827	117885
OVERHEAD DOLLARS			
ENGRG OHD	135307	3169	138476
MFG OHD	18242	8652	26894
MATL OHD			
ADM BASE	503726	128454	632180
ADM EXPENSE	52388	13359	65747
G AND A BASE	556114	141813	697927
G&A EXPENSE	37260	9501	46761
OTHER COSTS			
IDWA			
GFAE TYPE MATL			
PACKAGING			
P.L.I.			
TOTAL COST	593374	151314	744688
PROFIT	59337	15131	74468
FCCM INPLANT	7964	5369	13333
FCCM OUTPLANT			
SALES PRICE	660675	171814	832489

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COST AND/OR PRICE SUMMARY   DATE 02/15/80   OPTION

RFE 7776 NAS42 10160 PLANNING PRICE TASK 5 (CY 80$)

Table 6.2
Sheet 7 of 9

	ON-SITE	OFF-SITE	TOTAL
LABOR HOURS			
ENGINEERING	11640	5760	17400
PRODUCT SUPPORT			
DEVELOPMENTAL	30129	688	30817
MFG TECH	0		0
TOOL DESIGN	0		0
TOOL FAB	0		0
PRODUCTION			
PLAN & LIAISON	2923		2923
PROD SERVICES	7231		7231
TOOL SERVICES	1356		1356
QUALITY ASSURANCE	1959		1959
QUALITY CONTROL	3820	208	4028
DIRECT LABOR DOLLARS			
ENGINEERING	166310	95888	262198
PROD SUPPORT			
* SUB-TOT-ENGR *	166310	95888	262198
DEVELOPMENTAL	317258	7245	324503
MFG TECH			
TOOL DESIGN			
TOOL FAB			
PRODUCTION			
PLAN & LIAISON	25996		25996
PROD SERVICES	67610		67610
TOOL SERVICES	13248		13248
QUALITY ASSUR	21196		21196
QUALITY CONTROL	40301	2194	42495
* SUB-TOT-MFG *	488609	9439	498048
MATERIAL DOLLARS			
DEVEL MATL	45820		45820
TOOL MATL			
SUB-TOOLING			
PROD MATL			
OUTSIDE PROD			
* SUB-TOT-MATL *	45820		45820
OTHER DIRECT COST			
TRAVEL	101000		101000
FRINGE BENEFITS	314361	50557	364918
OVERHEAD DOLLARS			
ENGRG OHD	146353	14383	160736
MFG OHD	684053	1416	685469
MATL OHD			
ADM BASE	1900596	171683	2072369
ADM EXPENSE	197671	17855	215526
G AND A BASE	2098357	189538	2287895
G&A EXPENSE	140590	12699	153289
OTHER COSTS			
IDWA			
GFAE TYPE MATL			
PACKAGING			
P.L.T.			
TOTAL COST	2284767	202237	2487004
PROFIT	228477	20724	248701
ECON INFLANT	46557	4788	51345
ECON OUTPLANT			
SALES PRICE	2559801	227249	2787050

Table 6.2
Sheet 8 of 9

COST AND/OR PRICE SUMMARY DATE 02/15/80 OPTION

RFF7776 NASA2 10160 PLANNING PRICE TASK 6 (CY 80$)

	ON-SITE	OFF-SITE	TOTAL
LABOR HOURS			
ENGINEERING	9920	6480	16400
PRODUCT SUPPORT			
DEVELOPMENTAL	4000	10352	14352
MFG TECH	0		0
TOOL DESIGN	0		0
TOOL FAB	0		0
PRODUCTION			
PLAN & LIAISON	388		388
PROD SERVICES	960		960
TOOL SERVICES	180		180
QUALITY ASSURANCE	260		260
QUALITY CONTROL	480	1888	2368
DIRECT LABOR DOLLARS			
ENGINEERING	149878	111510	261388
PROD SUPPORT			
* SUB-TOT-ENGR *	149878	111510	261388
DEVELOPMENTAL	42120	109428	151548
MFG TECH			
TOOL DESIGN			
TOOL FAB			
PRODUCTION			
PLAN & LIAISON	3849		3849
PROD SERVICES	8876		8876
TOOL SERVICES	1759		1759
QUALITY ASSUR	2813		2813
QUALITY CONTROL	5064	19918	24982
* SUB-TOT-MFG *	64581	129346	193927
MATERIAL DOLLARS			
DEVEL MATL			
TOOL MATL			
SUB-TOOLING			
PROD MATL			
OUTSIDE PROD			
* SUB-TOT-MATL *			
OTHER DIRECT COST			
TRAVEL	423056		423056
FRINGE BENEFITS	102940	115611	218551
OVERHEAD DOLLARS			
ENGRG OHD	131893	16727	148620
MFG OHD	90413	19402	109815
MATL OHD			
ADM BASE	962761	392596	1355357
ADM EXPENSE	100127	40830	140957
G AND A BASE	1062888	433426	1496314
G&A EXPENSE	71213	29040	100253
OTHER COSTS			
IR&D			
GFAE TYPE MATL			
PACKAGING			
P.L.I.			
TOTAL COST	1134101	462466	1596567
PROFIT	113410	46247	159657
FCCM INPLANT	12537	14752	27289
FCCM OUTPLANT			
SALES PRICE	1260048	523465	1783513

COST AND/OR PRICE SUMMARY DATE 02/15/80 OPTION

RFE7776 NASA2 10160 PLANNING PRICE TASK 7 (CY 80$)

Table 6.2
Sheet 9 of 9

	ON-SITE	OFF-SITE	TOTAL
LABOR HOURS			
ENGINEERING	24960	1440	26400
PRODUCT SUPPORT			
DEVELOPMENTAL	0		0
MFG TECH	0		0
TOOL DESIGN	0		0
TOOL FAB	0		0
PRODUCTION			
PLAN & LIAISON	0		0
PROD SERVICES			
TOOL SERVICES			
QUALITY ASSURANCE	0		0
QUALITY CONTROL	0		0
DIRECT LABOR DOLLARS			
ENGINEERING	421591	24725	446316
PROD SUPPORT			
* SUB-TOT-ENGR *	421591	24725	446316
DEVELOPMENTAL			
MFG TECH			
TOOL DESIGN			
TOOL FAB			
PRODUCTION			
PLAN & LIAISON			
PROD SERVICES			
TOOL SERVICES			
QUALITY ASSUR			
QUALITY CONTROL			
* SUB-TOT-MFG *			
MATERIAL DOLLARS			
DEVEL MATL			
TOOL MATL			
SUB-TOOLING			
PROD MATL			
OUTSIDE PROD			
* SUB-TOT-MATL *			
OTHER DIRECT COST			
TRAVEL	35533		35533
FRINGE BENEFITS	202364	11868	214232
OVERHEAD DOLLARS			
ENGRG OHD	371000	3709	374709
MFG OHD			
MATL OHD			
ADM BASE	1030988	40302	1070770
ADM EXPENSE	107171	4191	111362
G AND A BASE	1137659	44493	1182152
G&A EXPENSE	76023	2981	79204
OTHER COSTS			
IDWA			
GFAE TYPE MATL			
PACKAGING			
P.L.I.			
TOTAL COST	1213682	47674	1261356
PROFIT	121388	4747	126135
FCCM INPLANT	18497	1046	19543
FCCM OUTPLANT			
SALES PRICE	1353767	53267	1407034

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6.3 Summary of Material Planning Cost Estimates

This section gives a summary 'n Table 6.3 of overall estimates of material required to accomplish subject program. Where appropriate these data are based on CH-46 and CH-47 experience. This is the case in Task I (Blades). A detailed breakdown for Task 3 is given in Table 6.3.1 because this includes major cost elements associated with subcontractor vendor engineering and design support for development of the flight control processor units. These are based on data from Minnesota Honeywell.

TABLE 6.3 SUMMARY MATERIAL PLANNING COST ESTIMATES

		Cost	Nonrecurring
Task 1	Blades (17)	$186,400	$ 78,000
Task 2	Hubs (81)	250,236	22,500
Task 3	Fly-By-Wire		
	o Aircraft	555,678	5,230,262
	o Spares	323,649	
	o Iron Bird	417,391	
	o Qualification	146,824	
	Wind Tunnel Controller	13,300	
Task 4	Operational/Qualification Testing	174,800	
Task 5	XV-15 Modifications	45,820	
Options	(Incremental 6 Blades, plus 2 Hubs)	121,642	
TOTAL MATERIAL COST			$7,566,502

TABLE 6.3.1 BREAKDOWN OF FLY-BY-WIRE CONTROL SYSTEM COSTS
Based On Information From Engineering And Minnesota Honeywell

Task #3 Fly-By-Wire		Unit Cost	Total Cost	Nonrecurring
Flight Control Processor				
Engineering & Design	A/R	-	-	$4,000,000
Vendor Flight Worthiness	A/R	-	-	250,000
Vendor Field Support	A/R	-	-	150,000
Test Equipment	A/R	-	-	400,000
Computer Control Unit For Aircraft				
Flight Control Processor	3	$85,560	$256,680	
Rate Gyro Assy	3	5,556	16,668	
Normal Accelerometer Assy	1	4,000	4,000	
Position Transducer Assy	4	1,667	6,668	
Control Panel	1	9,334		
Maintenance Unit	1	40,000	40,000	
Computer Control Unit Spares For Aircraft				
Flight Control Processor	2	85,560	171,120	
Rate Gyro Assy	2	5,556	11,112	
Normal Accelerometer Assy	1	4,000	4,000	
Position Transducer Assy	3	1,667	5,001	
Control Panel	1	9,334	9,334	
Maintenance Unit	1	40,000	40,000	

TABLE 6.3.1 (CONTINUED)

		Unit Cost	Total Cost	Nonrecurring
Computer Control Unit-Test-Iron Bird				
Flight Control Processor	3	$85,560	$256,680	
Rate Gyro Assy	3	5,556	16,668	
Normal Accelerometer Assy	1	4,000	4,000	
Position Transducer Assy	4	1,667	6,668	
Control Panel	1	9,334	9,334	
Maintenance Unit	1	40,000	40,000	
Computer Control Unit - Qual. Test				
Flight Control Processor	1	85,5[illegible]	85,560	
Rate Gyro Assy	1	5,556	5,556	
Position Transducer Assy	1	1,667	1,667	
Wind Tunnel Controller	1	13,300	13,300	
Engine Control Actuators				
Engineering Testing & Flight	A/R	-	-	$230,086
Tooling & Planning	A/R	-	-	130,176
Field Support	A/R	-	-	20,000
N1 Actuators	A/R	-	-	50,000
A/C Hardware				
Actuators (Flt Cntl)	8	14,041	112,328	
Actuators (N1)	2	40,000	80,000	
Quadrants	1	15,000	15,000	
Cable Assy	1	15,000	15,000	

TABLE 6.3.1 (CONTINUED)

		Unit Cost	Total Cost	Nonrecurring
A/C Spares				
Actuators (Flt Cntl)	2	$14,041	$28,082	
Actuators (N1)	1	40,000	40,000	
Quadrants	1	15,000	15,000	
Iron-Bird-Test				
Actuators (Flt Cntl)	1	14,041	14,041	
Actuators (N1)	1	40,000	40,000	
Quadrant	1	15,000	15,000	
Cable Assy	1	15,000	15,000	
Qual. Test Units				
Actuators (Flt Cntl)	1	14,041	14,041	
Actuator (N1)	1	40,000	40,000	

7.0 REFERENCES

1. NASA CR 152336-1 "Preliminary Design Study of Advanced Composite Blade and Hub and Nonmechanical Control System for the Tilt-Rotor Aircraft". Volume 1 Engineering Studies. Alexander, et al, November 1979 (Boeing Document D210-11569-1)